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A cost-benefit analysis of the risk control options towards mitigating maritime hazards leading to injuries and fatalities in tanker shipping companies: a critical and thought provoking case study

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A COST-BENEFIT ANALYSIS OF THE RISK CONTROL OPTIONS TOWARDS MITIGATING MARITIME HAZARDS LEADING TO INJURIES AND FATALITIES IN TANKER SHIPPING COMPANIES:

A critical and thought provoking case study

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Declaration

I certify that all materials in this dissertation that is not my own work have been identified and that no material is included for which a degree has previously been conferred on me. The contents of this dissertation reflect my own personal views and are not necessarily endorsed by the university.

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Abstract

This project aims are (a) to discover how the implementation of Risk Control Options (RCO) reduces the probability of seafarers' exposure to certain unwanted events and (b) to determine ways to reduce the losses of millions of dollars by mitigating injuries and fatalities on tanker vessels. For this reason, this dissertation will (a) introduce the importance of RCOs, (b) reinforce an incremental progress in defining the negative value of accident costs in a company's budget and (c) will identify the reasons that companies suffer from financial losses. It highlights the deficiencies leading to injuries and fatalities such as the lack of cost-benefit analysis from the corporate side, combined with the companies' ideology to indirectly reduce the implementation costs of RCOs. Irrespective of the difficulty to calculate (a) the risk reduction percentages of RCOs, (b) all event trees and (c) the tangible and intangible costs of injuries and fatalities, this investigation proves that any implementation in RCOs has a direct impact on reducing the financial losses of tanker shipping companies.

The scope of this case study is a scientific approach toward risk and cost reduction from the implementation of RCOs, with an ulterior incentive of gaining economic benefits. This study probes the knowledge of ten senior managers, who serve as responsible decision makers in ten different tanker-shipping companies, engaged in the Aframax and Panamax sector. It also draws upon interviews with senior managers combined with cost-benefit and risk analysis reports in order to reveal the companies' reasons for indirectly investing in RCOs. This thesis further outlines circulars to bolster researchers' claims by the monetary threshold of the Gross and Net Cost of Averting a Fatality (GCAF, NCAF) from International Maritime Organization (IMO). In an effort to define an RCO as cost-effective, this project will use data from projects of the Marine Environmental Protection Committee (MEPC) and Maritime Safety Committee (MSC).

The current project integrates four collision, grounding, explosion, and fire preventative RCOs so as to extract its conclusions. The important measurable variables of this study are the direct and indirect costs of injuries and fatalities, while with reference to RCOs, the level of risk reduction of saved lives, the cost of implementing an RCO, the economic benefit deriving from that RCO and finally its individual GCAF and NCAF. Important variables that are ignored are oil spill reduction in tons and the potential cost of averting one tonne of oil spilled since they are out of the scope of this study. It has been found that RCO1: hot work procedure training and RCO2: engine room additional emergency exit maintain significantly low GCAF rates, and, as a result, are named as cost-effective in comparison to RCO3: active steering gear redundancy and RCO4: navigational sonar. Furthermore, it has been proved that a single fatality in tanker shipping is expected to generate a total loss of $3.400.000, while a disabling injury results in a loss of $82.500. Finally, the current case study benchmarks against previous recommendations, found in similar Formal Safety Assessments (FSA) for tanker vessels, demonstrating novel road-signs towards regaining companies' capital.

Key words: Direct and indirect costs, disabling injury and fatality, risk control option

Table of Contents

List of Figures

List of Tables

Glossary

ALARP	As Low As Reasonably Practicable
CAF	Cost of Averting a Fatality
CBA	Cost Benefit Analysis
DNV	Det Norske Veritas
DPA	Designated Person Ashore
ECR	Engine Control Room
EMSA	European Maritime Safety Agency
ER	Engine Room
FP	Fire Protection
FSA	Formal Safety Assessment
GCAF	Gross Cost of Averting A Fatality
ICF	ICF Kaiser Consulting Group
IMO	International Maritime Organization
ISGOTT	International Safety Guide for Oil Tankers and Terminals
LTIR	Lost Time Injury Frequency Rate
MEPC	Marine Environmental Protection Committee
NASF	Non Acidental Structural Failure
NCAF	Net Cost of Averting A Fatality
NSC	National Safety Council
NPV	Net Present Volume
OCIMF	Oil Companies International Marine Forum
OECD	Organization for Economic Co-operation and Development
PLC	Potential Loss of Cargo
PLL	Potential Loss of Life
PLP	Potential Loss of Property
P&I club	Protection and Indemnity insurance Club
RCO	Risk Control Option
SIRE	Ship Inspection Report Programme
SOLAS	Safety of Life at Sea
UK	United Kingdom

CHAPTER No1: INTRODUCTION

1.1 Statement of the problem

Nautilus International (2017) disclosed that there has been a large increase in the number of detained ships due to intolerable safety standards on vessels. Additionally, there is a consensus among scientists (Aviva, 2011; Stopford, 2013) that maintaining adequate safety standards in the maritime domain might be challenging, especially by analyzing the last prolonged and deep shipping crisis of 2008 and the subsequent drop in freight rates to 60% less than normal, as reputed.

For as long as shipping evolves, the age-old question remains "*Are there any appreciable amounts allocated from the corporate side towards limiting injuries and fatalities on board?".* There are those who believe that the answer is a profound "NO" (IHS Maritime, 2009-2013; Burkhard, 2016), due to the numerous fatalities on a world wide scale, leading to the main reason for this analysis and the key problem that this project aims to resolve.

From another point of view, Clarke and Cooper (2004) extensively referred to RCOs as the actions performed with the aim of mitigating the consequences of accidents or reducing the frequency of failures. It is estimated (Aviva, 2011) that RCOs for the prevention of marine related accidents are mainly absent, leading one to speculate that any correlation among cost and effectiveness will be regrettably low. It is further believed (Aviva, 2011) that the problem stems from employers themselves that do not know the economic benefits of an RCO, triggering, even more, this problem to grow. According to the British safety council, benefits are unknown by senior safety managers, revealing the main cause that leads to insufficient investments on RCOs (Stopford, 2013). Furthermore, evidence showed that 54% of employers would be willing to increase their safety investments if they were aware of a profound return on investment (Aviva, 2011). For all these reasons, there is a need to resolve these obstacles and limit the assumption that there is a blockage in the scientific establishment, speculating "*Where is the evidence?*".

It is also believed (Oxenburgh & Marlow, 2005) that something stimulated the absence of proactive thinking as well as the absence of investment on risk prevention framework in shipping companies. Some (Van Erp & Reniers, 2016) say that it is senior managers' lack the knowledge to illustrate the financial impact of injuries and fatalities, while others claim that it is the high price of RCOs to avert these mishaps. Likewise, what is not yet clear are the financial benefits compared to the financial losses of injuries and fatalities. Doubtless, the existing accounts fail to resolve the contradiction between company's losses and manager's financial knowledge. Investigating the emerging benefits of an accident prevention program, Otway (2001) and Rikhardsson (2004) insist that financial benefits are measurable, verifying once more managers' limited knowledge on the economic aspect of safety. According to Van Erp and Reniers (2016), another major problem is that some managers insist that there is no tangible and quantifiable way of explaining the benefits of proactive accident prevention programs.

Furthermore, the so far experimental data is rather controversial, while it seems that there is a lack of general agreement regarding the employer's costs in case of injuries and fatalities. With shipping companies thinking that insurance companies (in case of an accident) pay everything, they neglect to separately identify the direct, indirect, unknown and employer's losses (Van Erp & Reniers, 2016).

Furthermore, the most striking evidence that hampers any investment in RCOs comes from Gosselin's (2005) research, which suggests that specific methods for calculating direct and indirect injury and fatality losses are too generalized or universal instead of being focused on the specific tanker shipping industry per se. Overall, since much of the published research on this issue is indeed problematic, this project aspires to find a remedy among all these aforementioned obstacles.

1.2 Purpose and outline

Initially, the current research is specifically focused on how a tanker shipping company will financially benefit from implementing an RCO or be impaired by not investing in an RCO. In addition, it explores the convergence of two major components, researchers and senior risk managers, so as to reveal why ship-owners remain skeptical towards investing in RCOs (Moore, 2016; Mantel, 2017). It is time to commit to finding RCOs' benefits, risk reduction percentages as well as pertinent costs as of the establishment in RCOs.

This research will furnish a critical analysis of senior managers' financial knowledge and how it influences the economic 'viability' of their tanker shipping companies. The purpose of this introduction is to furnish a preliminary overview of the main obstacles that companies are facing with respect to the cost of safety. In this case, costs will be seen from two different angles, (a) cost as an expense/loss and (b) cost as an investment. With respect to the latter, the current study is structured and divided into three main areas:

- the direct, indirect and employers' costs relating to marine injuries and fatalities,
- the cost/net present value of an RCO,
- the economic benefits of an RCO.

The key purpose is to rank, in a traceable and auditable manner, four proposed RCOs to arrive at a potential decision making mechanism from a cost-efficiency perspective and keep risks As Low As Reasonably Practicable (ALARP).

1.3 Significance of research study

According to Vanroye and Mol (2009), the shipping community faces difficulty in finding qualified individuals on a corporate level. It was further disclosed by Kamil and Deha (2001) that Designated Persons Ashore (DPAs) with several years of experience as ex-captains on vessels are employed in executive positions but maintain insignificant budgetary knowledge as well as accident prevention vision. Similarly, Stopford (2013) has highlighted the need to disseminate financial knowledge from the higher management to the lower ranks. According to Kristensen (2011), the absence of scientific eagerness backed by lack of safety framework constrains the viability of the shipping company itself.

On this basis, the project's findings will make an important contribution to the financial safety sector, proving that any pressure allocated on risk managers to abide by commercial interests hampers their innovation and the free flow of knowledge (Kamil & Deha, 2001; Kristiansen, 2013; Stopford, 2013). This is the first study to undertake a longitudinal analysis to clarify the tangible and non-tangible costs that a safety manager should be aware of and the main factors that hinder decision makers from investing in RCOs.

Consequently, this dissertation aspires to *sway* the readers regarding the imperative need for safety investment into tanker shipping companies, in an effort to mitigate the administrative failures and limit the injuries and fatalities (IMO, 2017). The project's conclusion and recommendation section explains the need to advance the understanding of safety managers, thus furnishing novel insights that intend to increase profitability and provide ‘contagious’ views in an effort to mitigate financial losses to companies’ dispensable budgets.

1.4 Research aim and objectives

The central of this investigation is to examine the costs of RCOs, focusing exclusively on losses emerging from injuries and fatalities in the tanker shipping industry. Any extracted findings and conclusions are intended to contribute to the evolution of safety above the core standpoint of decision makers and stimulate the emergence of a high standard safety investment towards accident prevention programs.

More precisely, the study explores "*why*" decision makers should invest in RCOs, by providing proof that marine injuries and deaths are indeed avoidable when adequate safety investments are applied. Initially, this dissertation seeks to remedy these problems by analyzing estimates of losses due to injuries and deaths. At the second stage, this research critically examines the magnitude of injuries and fatalities on board ships as well as the monetary weight of RCOs so as to alleviate the financial losses from these marine accidents.

According to Gosselin’s research (2005), there is difficulty correlating one specific accident prevention program with its own benefits when multiple measures are applied at the same time in one shipping company. Thus, the aim of this study is to shine new light on these debates through an examination of significant cost-savings which can emerge from a safety investment. It is important to note that this report was designed in such a way as to reveal that even a minimal investment can produce great results in any maritime related sector and, specifically, the tanker shipping industry. However, existing accident prevention programs have worked for 20 years, begging the question, "*why* should *ship-owners change them now?*".

To make this topic more relevant, this study will review data from some maritime hazards, aiming to reveal that tanker accidents resulting in fatalities are by far the most costly in comparison with barges, tows, tugs and passenger vessels. In the same vein, it will attempt to provoke decision makers by reminding them that Protection and Indemnity (P&I) insurance clubs do not cover the whole cost of injuries or fatalities, but that there are also employers' costs that are usually unknown to senior managers (Dorman, 2000).

In addition, this thesis contests the claim that "*safety managers do not deviate from safety investment*". In fact, the current study addresses the reasons of why managers deviate from safety investments, so as to stimulate tanker shipping companies that have faced huge financial losses to promptly invest in RCOs.
With reference to the latter, the current project will comprise of one main research question, divided into four sub-questions.The main question is:

"Which are the interrelated costs of RCOs with regard to maritime injuries and fatalities on Panamax and Aframax tankers?"

This question is further divided into four sub-questions with regard to the tanker shipping industry:

1. Why tanker-shipping companies indirectly invest in RCOs?
2. What is the difference of disabling injuries and fatality costs in tanker shipping compared to those in passenger and bow/barge/tug industry?
3. What are the reasons that restrict the decision makers from investing in RCOs?
4. What is the level of senior managers' knowledge with respect to the financial aspect of marine injuries, fatalities and RCOs?

CHAPTER No2: METHODOLOGY

2.1 Definition of case study

Irrespective of the individual researchers' background or their wording techniques Numan (1992), Yin (1994) and Stake (1995) coincided in several points with respect to this chosen research strategy, the case study. The initial approach to the subject matter was described by Numan (1992), who classified the case study as "*the investigation of a single instance in the context in which it occurs*". Based on this statement, Yin (1993) went one step further and added that a case study can be defined as "*a unit of analysis".* The more precise definition was given by Stake (1995) who developed the claim that it is "*a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence*".

2.2 Strengths and Weaknesses of Case Studies

As stated by Patton (2014), a case study is surrounded by complexity since often alternative interpretations can emerge from analyzing the same subject. In the same vein, Merriam (1998) revealed that this method is considered to be the ideal method by which to answer a research question. In fact, not only is the data more accessible than in conventional research reports, but important insights can be furnished through such a technique.

On the contrary, certain drawbacks, attributable to practical constraints, may impair the conduct of a case study. Hence, a number of caveats seem prudent to note and address in advance. For example, Yin (2013) affirmed that a case study may consist of exaggerated or oversimplified content, orienting researchers towards mistaken conclusions. Bryman and Bell's (2007) assertion focused mainly on qualitative studies, revealing that such studies often lack of integrity when it comes to the researchers' viewpoint. The last author, however, neglected to note that the researcher becomes the key 'tool' who analyzes and collects data, which in fact leaves the researchers dependent on their own abilities.

The principle drawback remains the investigator, who may rely on material of marginal significance, which has been misjudged or wrongly illustrated. Hence, the author and the reader have a duty to abstain from potential biases involved. With regard to validity and reliability, Marshall's and Rossman's (2006) arguments reveal that numerous case studies have been significantly impaired by the absence of due diligence during the construction, analysis or collection of empirical data.

2.3 Justification of the chosen strategy

Even if Emilia (2008) stated that a case study is mainly chosen due to the complexity of issues involved, Creswell (1994) argued that a case study of exploratory purpose may be used to gather descriptive data that will breed innovative propositions as well as insights. Emilia (2008) further believed that a case study may conceal numerous gaps in research, while Connole, Smith and Wiseman (1993) insisted that it can still serve as a useful tool for investigating multi-faceted phenomena. On this basis, the aim of the chosen strategy is to give shipping companies access to key qualitative data so as to avoid potential bankruptcy due to multiple financial losses from injuries and fatalities. Thus, since data is easy to collect and verify, the case study is flexible enough to enable the researcher to portray and reveal the shipping industry's reality.

2.4 Definition of semi-structured interviews

Although the term *interview* has been defined by many researchers from their respective standpoints, the current study chooses Kothari's definition (2009) which describes it as a thorough conversation among two individuals: the interviewer and an informant.

The interviewer aspires to extract key data towards fulfilling his dissertation, which at this point is the so called 'case study'. Yet this independent piece of work uses this term interchangeably with Krishhnaswami and Ranganatham (2009) to present the interview as a '*detailed conversation'* surrounded by an oral '*examination'* on the interviewee's background and standpoint on key issues relevant to the thesis topic. This enables the interviewer to perform primary research in an effort to collect data directly from the real world.

With respect to the three types of interviews, structured, semi-structured and unstructured, the semi-structured interview is preferable for the this project. Interviewees shall express their perceptions enabling the researcher to gently collect genuine qualitative data. There is a consensus among researchers (Wengraf, 2001**;** Myers, 2008) that probing is the technique primarily utilized to amplify an unanswered or partially answered inquiry with the intention of clarifying the interviewee's response. By drawing on the concept of semi-structured interviews, Galletta (2013) was able to show that the collection of factual and descriptive data is imperative in order for accurate conclusions to emerge. In his review, he revealed that the interviewer can engage in fruitful testimonies around the chosen '*argument*', vital for the enhancement of the thesis.

2.5 Strengths and weaknesses of interviews

Panneerselvam (2008) claimed that when an interviewer is passionate about his assigned piece of work, interviewees will be stimulated to genuinely fulfill his scope. The main principle according to Chandrashekara, Shivakumar, and Ramachandra (2006) is that an atmosphere of confidence will yield positive results by enabling delicate and complex topics to be explored. Taking a middle-ground position, Gupta (2010) advised the interviewers to shift their inquiry to a softer sub-theme whenever the interviewee feels undue tension due to sensitive questions. Any facial expression, body language or intonation will instantly reveal to the interview the interviewee's feelings. This will increase the document's validity and will give an extra inducement to cautiously examine the issue in depth, by appending new dimensions to the data collection process. Conversely, Kothari (2009) claimed that a right combination of probing accompanied with a neutral manner guarantees that an important subject is covered, by giving an opportunity to the interviewer to extract controversial information.

Nonetheless, certain drawbacks may emerge that could minimize the efficiency of the final outcome. Based on Gillham's (2000) viewpoint, the one on one interview could become challenging if it is not approached with caution. Aside from the time necessity as far as the formulation of the inquiry is concerned, wide re-analysis of the interviewees' responses is inevitably required, so as to elucidate the key concepts. Similarly, Panneerselvam (2008) emphasized the assessor's need to appoint the precise place and time for the execution of the interview, which must be adjusted based on the interviewee's daily timetable.

Interestingly, Gupta (2010) is concerned that when the number of participants is limited, the anonymity of the informant might be threatened. In such cases, any response might be impaired. Bryman and Bell (2007) insisted that personal bias persists as a commonplace issue due to errors which are unconsciously expressed by each side during the interview process. Being more of a hindrance than a help, an assessor must prudently distinguish an arising inconsistency owing to limitation of memory, exaggeration or dishonest statements. As Oppenheim (1992) recognized, respondents may not testify frankly for fear of being criticized, but instead choose to shift their replies to preferable ones in favour of the interviewer. Interestingly, the interviewer ought to avoid any kind of sympathy when it comes to problems by constantly preserving utmost objectivity.

2.6 Justification of the chosen semi-structured interviews

Personal semi-structured interviews were finally utilized with the intention of exploring safety managers' and DPAs' standpoints since such a way intends to strike the desirable equilibrium of freedom and order. Even if it is not as constricting as a survey, or totally unstructured as unstructured interviews, it will reserve the uniformity of all interviewees involved.

Besides, a structured approach would not add any value because of the presence of standardized inquiries, which hamper the execution of an in-depth investigation. A noteworthy time for the conduct of the chosen unstructured interviews, in fact, validates the broad range of this investigation. Therefore, it was considered to preserve the main inventory of open-ended questions that will be expressed through semi-structured interviews. In the end, it will precisely furnish evidence of why this case study was carried out, will contrast participants' experiences and standpoints by separating all principal barriers of the interview so as to provide a more cost effective, timely and concise outcome.

2.7 Definition of secondary data

Denzin and Lincoln (2000) defined the term '*secondary* data' as the data collected from multiple sources with the aim of creating appropriate conclusions from analyses conducted by individuals, organizations, agencies and other relevant parties.

Taking a middle-ground position, Vartanian (2011) and Crossman (2013) affirmed that non-governmental institutions maintain a tendency of systematically gathering information to the satisfaction of their own exclusive needs. Hence, when data of this kind is used for in depth analysis, filtering of such records seems imperative, since the original purpose may differ from the researcher's.

2.8 Advantages and disadvantages of the secondary data collection tool

Apropos of the advantages of secondary data, Wolcott (2009) highlighted the reduced need for time and financial assistance during the undertaking of the project. However, Russell and Ryan (2009) conclusively showed that quality resources may, in fact, require a small amount of money. Then again, analyzing and mining of data from books could turn out to be a positive process since it may furnish the study with fruitful information which could ultimately stimulate a student to launch an investigation. Silverman (2009) pinpointed that this procedure enables the researcher to discover a large number of sources on any chosen topic.

However, Wolcott (2009) and Crossman (2013) acknowledged that even though the framework of a study might appear the similar with that of the investigator, the key topic may contain noticeable dissimilarities. Based on Denzin's and Lincoln's (2000) discussion, when the focal point of a document does not directly correlate to that of the investigator, extensive research seems prudent to reveal the hidden argument.

2.9 Justification of the chosen data collection tool

Initially, secondary data was initially chosen in order to merge any extracted findings with those of semi-structured interviews and gain insight into the theoretical implications of this topic. Additionally, qualitative interviews were utilized due to the exploratory purpose of this research, which aims to clarify the stated hypothesis. In fact, the multi-faceted topic necessitates in depth research; thus, the aforementioned combination of tools will explore the controversial costs and benefits emanating from injuries, fatalities, and RCOs. The current case study consists of data from technical reports, safety analysis records and studies on the costs of safety. Hitherto, relevant data to the support the current investigation found only from a few researchers who investigated the costs of RCOs in tanker shipping industry. Yet, the researcher was willing to test this hypothesis since such necessary research will enable him to deepen his expertise in such a challenging industry.

2.10 Method of analysis of interview data

Due to (a) the absence of time, (b) the allocation of funds to define and name every single theme, (c) process a computer software program and (d) support the transcription analysis, a coding program was not utilized. The interviews were not been recorded for confidentiality reasons, thus it was not possible to proceed with transcription and coding.

Each interview was between 20 and 45 minutes, with interview questions (see Appendices 1, 2) to serve as the main framework for the investigation. Eight DPAs and two Marine superintendents from 10 different Greek tanker shipping companies were investigated and responded to four semi-structured questions. Hence, each interview inquiry had a precise factor in the finding section ranging from 1 to 10 on the numerical axis and 10% to 100% on the percentage axis in the discussion section. For the conduct of this investigation, all ten Greek participants were allocated numbers from P1 to P10 as shown in Table 1.

Table 1: Allocation of numbers of ten interviewees

Interviewee No1	P1
Interviewee No2	P2
Interviewee No3	P3
Interviewee No4	P4
Interviewee No5	P5
Interviewee No6	P6
Interviewee No7	P7
Interviewee No8	P8
Interviewee No9	P9
Interviewee No10	P10

Owing to the active participation of all interviewees in their companies' activities, all of them opted for the absence of recording device; thus, notes were taken by hand. On this basis, the findings' section has been injected with English key-passages in an effort of enhancing reader's enlightenment.

Each interview was conducted in the respondents' working environment by previously forwarding an invitation to them through their respective Human Resource department. Managers were specifically chosen based on exceptional considerations owing to experience with injury, fatality and RCOs costs.

2.11 Limitations

Safety costs are considered in both the maritime domain and the academic realm as a vital cog that encompasses the safety and financial aspect of the shipping industry. Nonetheless, approaches of this kind may entail certain limitations.

- This dissertation will not generalize, but will be limited to crude oil Panamax (see Appendices 4, 5) and Aframax tankers (see Appendices 6, 7).
- The perspective of this case study excludes the safety regulatory framework, focusing exclusively on the price and emerging benefits of RCOs.
- Any associated risk to other stakeholders, i.e. crew's life of a third party ship in case of collision or environmental costs, lies beyond the scope of this study.
- The identification of costs, losses or expenses emerging from injuries and fatalities for society is also excluded from this investigation, limiting the study to the direct, indirect, unknown and employer's costs allocated to Aframax and Panamax tanker shipping companies.

- This study will not examine oil spills or property damage incurred by shipping companies and, as such, the study will focus on the maritime related injuries and fatalities.
- The reader should bear in mind that the study is based on IMO circulars, books, journals, internet sources and annual financial reports from various shipping companies.
- Due to the limited time and availability of funds, 10 interviews at 10 Greek shipping companies were conducted in one week at the end of August 2017, when participants had their main annual leave; such a narrow time frame compelled the researcher to lean on MEPC & MSC technical reports, books and safety journals.
- Along the same lines, finite publications might serve as another limitation since quantity and quality might prove to be insufficient in order to constitute fruitful evidence. Thus, any scarcity of substantial reports reflects the primary difficulty in gathering data for this research. In order to avoid a potential debate, confine any possible criticism, and restrict any general comments on the project's claims, the topic was strictly focused on crude oil tanker shipping.
- After meticulous research on the classified direct and indirect costs of injuries and fatalities for Aframax and Panamax tankers, the quantification section of this project will have to rely on a study by DeMarco, Frederick, and Thomas (1997).

2.12 Validity and Reliability

When it comes to the validity of a case study, it seems prudent to explain:

1. if the assessor will be able to obtain testimony that corroborates interviewees' credibility,

2. if the number of interviewees is efficient to precisely deduce the core argument, or
3. if the interviewer's questions were adequately formed so not to disorient interviewees' reply.

However, testimonials might be misrepresented or misapprehended even if due consideration has taken place (Erford, 2014).

With respect to the representativeness of the project's group, the number of respondents seems sufficient and valid since the topic is confined within the tanker shipping framework. Participant's standpoints may ultimately display a number of variations if they are compared with other shipping sectors, such as the bulk or container shipping industry. That is why this case study cannot be generalized.

It is essential to test the quality of this research in order to validate its credibility. On this basis, the overall quality of this investigation was considered, in an effort to avoid questions as to "why quality issues were not tackled?". Besides, according to Veal (2006), a study in order to be reliable it has to also be valid.

Therefore, before the conduct of the interviews, it has to be borne in mind that the reliability of the interviews can be weakened due to provocative remarks or a reciprocal misunderstanding that could cause lack of consistency in participants' responses. To avoid this problem, and enhance the project's reliability, the execution of the interview is conducted by utilizing the probing technique. The interview process was conducted in English, despite all interviewees being Greek nationals, so as to avoid misinterpretation of data. Irrespective of the small sample of participants, interviewees' replies manifested a certain degree of similarity, revealing that signs of reliability and consistency were indeed persistent in this case-study. In an effort to make the sampling process reliable, this project performed a random sampling verifying its validity since the sampling group consisted of different age groups, different sizes of companies, different years of service of participants and different ranks. Moreover, the project's findings proved to be in line with what has previously been accepted as true by past studies.

2.13 Ethical issues

Due to the conversational nature of interviews, adequate ethical standards ought to be applied. In fact, Patton (1990) and Traianou and Hammersley (2012) concluded that pre-emptive questions are utilized by individuals who conduct investigations in a progressive ethical manner in comparison to interviewers who are less vigilant. For this reason, the current project was approved by the Research Ethics Committee of World Maritime University.

In comparison with Patton's interpretation, Rehi and Nolan (1995) and Fisher (2007) revealed that the researchers must preserve such a code of conduct that will ensure that those involved in the tanker industry will be incontrovertibly safeguarded. Additionally, the interviewer tries to confront conversational cues and delves deeper into the topic in a manner that common survey research will not allow. Confidentiality is maintained since participants' identities are kept private and their information is not to be disclosed.

Furthermore, Gillespie (1995) and Bloomberg and Volpe (2015) asserted that it is crucial to obtain consent before publication since the interviewer ought to request permission for stating anonymously the interviewee's testimonials. Besides, ethical permissions constitute one of the fundamental components of researcher activities. The interviewee must be fully informed regarding the nature of the study by bearing in mind the right to refuse or to reply to any inquiry. An informed consent shall include unspecified risks which could emerge during the interview. Besides, it is prudent to consider, in advance, any consequences or negative ramifications involved that may harm the interviewee, even if the interview is executed as planned (Patton, 1990; Roberts, 2010).

CHAPTER No3: PREAMBLE OF LITERATURE REVIEW

3.1 Background of literature review

Burkhard (2016), on behalf of the Institute of Shipping Economics and Logistics, provided the figures in Table 2 that reveal a thorough distribution of number and percentages for merchant vessels of 500 gross tons and over, separated into different casualty categories. Based on these results it has been proved that irrespective of the number of fatalities, foundering casualties account for 37.2% of the total share on a worldwide scale followed by grounding (24.2%), collision or contact (15.1%), fire or explosion (12.8%) and machinery casualties (8.9%). Sush data reinforce the key objective of this project on finding the most cost-effective RCOs to mitigate maritime hazards in the crude oil tanker shipping industry. However, as extracted from IHS Maritime (2009-2013) (Table 3), crude oil tanker vessels experienced the fewest number of fatalites compared to other ship categories on a world wide scale between 2004 and 2013. Yet, as it will be explained furtherdown in this project, fatalities involving tanker vessels are the most expensive ones compared to other maritime sectors.

Table 2: Reported world total losses of ships by age separated at time of loss and by nature of casualty between 2004 - 2015

	0-4 years	5-9 years	10-14 years	15-19 years	20-24 years	25 years & over	Total	%
Nature of casualty	No	No	No	No	No	No	No	Share of total
Collision or contact	12	7	7	14	29	75	144	15,1
Fire or explosion	3	8	5	8	18	80	122	12,8
Machinery	1	3	1	7	11	62	85	8,9
Foundering	16	20	7	22	48	241	354	37,2
Stranding / Grounding	11	10	10	13	43	143	230	24,2
Other	2	1	1	1	5	6	16	1,7
Total	45	49	31	65	154	607	951	100,0

Source: Burkhard, (2016) on behalf of Institute of Shipping Economics and Logistics

Table 3: Reported world fatalities separated by selected ship type categories between 2004 - 2013

Shiptype category	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total fatalities between 2004-2013
Bulk Carrier	13	7	27	39	15	55	48	39	8	15	266
Chemical Tanker	0	1	0	14	0	0	0	2	0	0	17
Chemical/Products Tanker	40	6	0	0	0	0	0	0	19	1	66
Container Ship	0	0	0	0	0	12	0	0	0	23	35
Crude Oil Tanker	0	0	2	0	0	0	0	5	0	0	7
Deck Cargo Ship	0	4	0	5	4	0	0	0	0	0	13
General Cargo Ship	188	166	148	199	156	327	144	72	112	33	1545
LPG Tanker	5	0	0		10	0	0	0	0	0	15
Offshore Tug/Supply Ship	0	0	0	0	0	0	10	0	0	0	10
Ore carrier	0	0	10	0	0	0	0	0	0	0	10
Passenger Ship	0	194	50	2	0	143	0	12	293	0	694
Passenger/Ro-Ro Ship (Vehicles)	289	2	1411	22	831	62	0	3013	103	137	5870
Passenger/Cruise	0	0	0	2	0	0	0	0	32	0	34
Ro-Ro cargo ship	0	0	3	10	7	1	0	0	1	0	22
Tug	0	0	3	7	0	0	1	0	2	11	24
Total	535	380	1654	300	1023	600	203	3143	570	220	8628

Source: IHS Maritime, (2009-2013)

MEPC 58/INF.2 also provided Figure 1 and revealed that, due to the introduction of international regulations (see Appendix 3), there was a gradual decrease in the navigational incident rate between 1978 and 2003 (groundings, collisions and contacts). In an effort to further mitigate accidents in tanker shipping industry, this project will propose four tangible RCOs and their respective cost effectiveness.

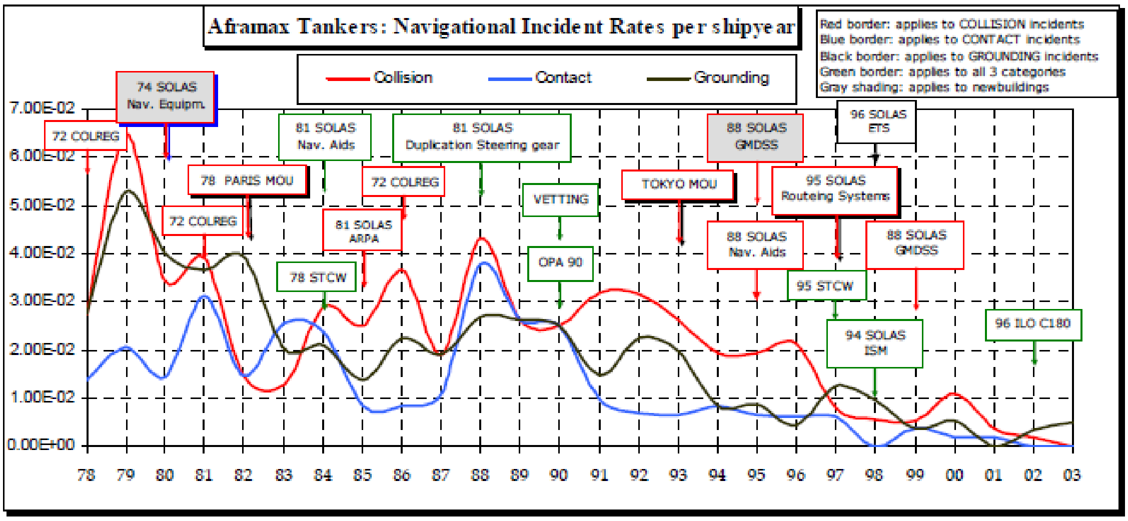


Figure 1: Navigational Incident rate versus regulations for Aframax tankers between 1978-2003

Source: MEPC, (2008)

However, the causes of injuries and fatalities have been the subject of intense debate within the scientific community. For this reason, a wealth of information has been extracted also from the European Maritime Safety Agency's (EMSA) statistics in 2017. In terms of shipboard accidents, the number one cause of injuries is slipping, stumbling and falling of persons on deck, followed by body movement injuries without any physical stress, and loss of control of machinery equipment (see Figure 2).

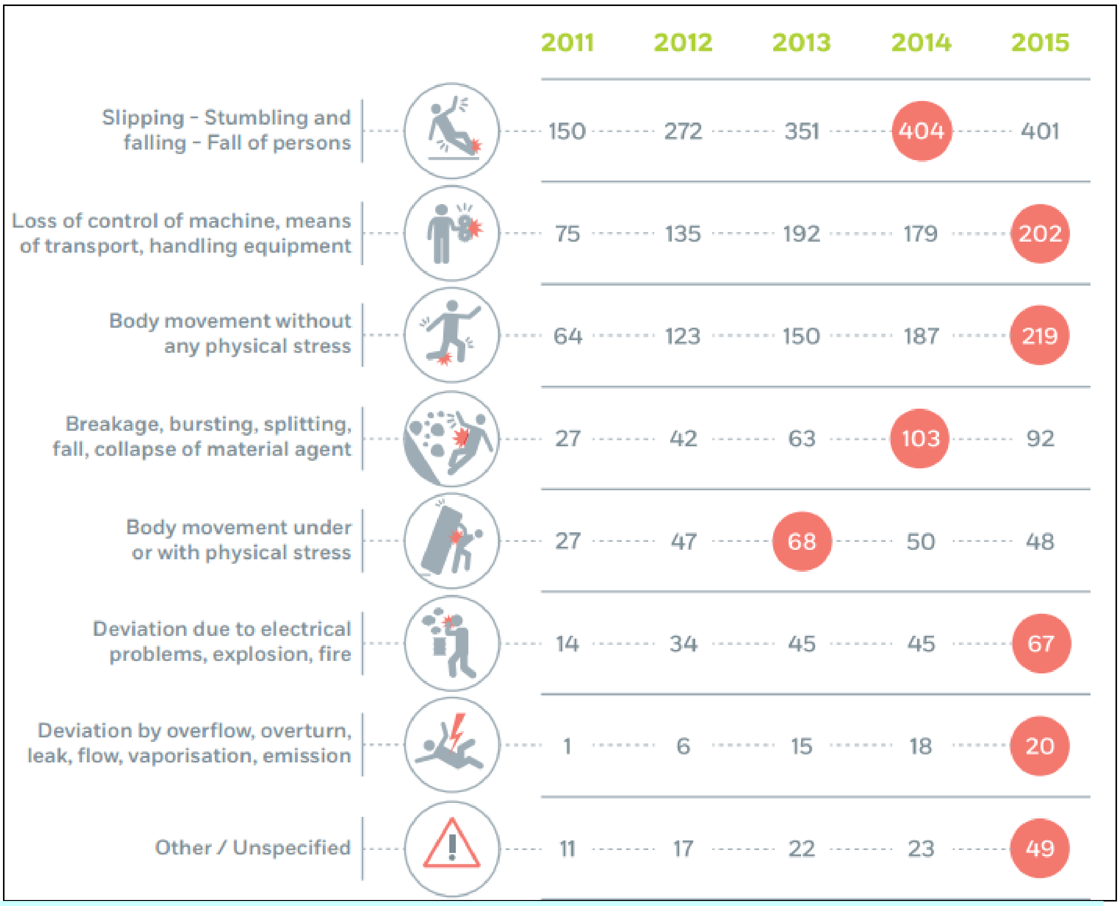


Figure 2: Main causes of shipboard marine related injuries from EMSA's reporting vessels between 2011-2015

Source: EMSA, (2017)

In terms of ship operation, injuries are mainly caused during vessels' contacts, fire/explosions, and collisions. On the other hand, the main shipboard reasons for such fatalities are slipping and falling (Figure 3), while for ship operation, they are flooding, collisions and capsizing.

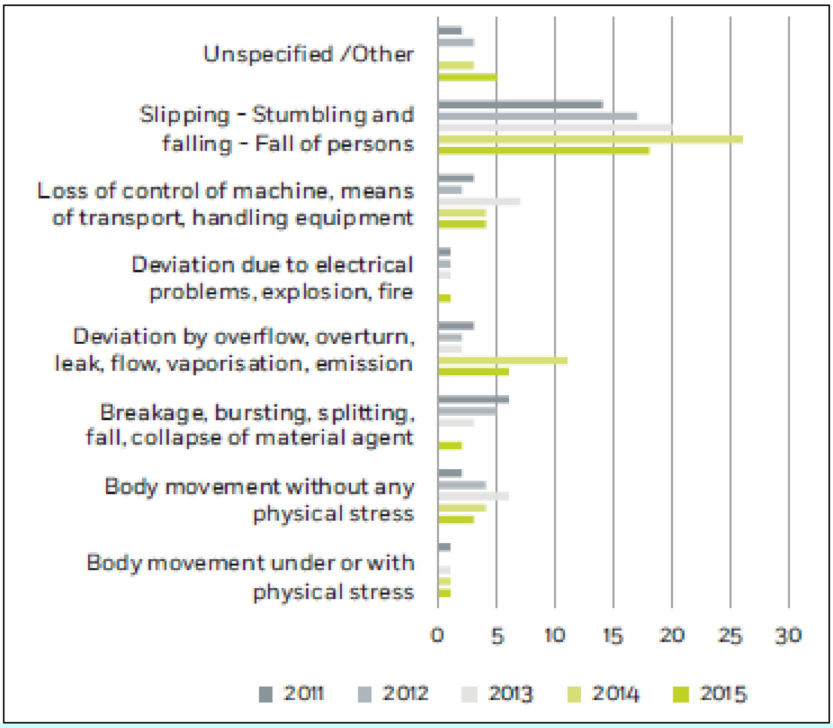


Figure 3: Distribution of shipboard marine fatalities from EMSA's reporting vessels between 2011-2015
Source: EMSA, (2017)

On the other hand, with respect to occupational accidents and shipboard related causes, fatalities from slipping and falling of persons are taking the lead. This issue received considerable critical attention when EMSA (2017), exposed that 51% of fatalities occurred on cargo vessels in general, including crude oil tankers.

3.2 Barriers that protract the emergence of injuries and fatalities

This chapter will furnish an initial point of view of the reasons that the abovementioned injuries and fatalities still exist at high levels.

It has been proved (Pierobon, 2012) that senior managers themselves partly restrict future investments because they do not adequately furnish to the financial department convincing evidence to support their budgetary requests. On the contrary, chief financial officers advocate that "the budgeting process would be less frustrating and safety managers would see more money for their departments" if RCOs were supported with convincing financial evidence. It is clear that the absence of a cost-benefit analysis could not support the safety managers in substantiating their point to financial executives so as to approve the initiation of RCOs.

From another perspective, Brody, Litourneau, and Poirier (1990) and Jalon et al. (2011 a,b) believe that companies allocate very limited capital to safety investments just to cover the fear of being exposed to financial losses from accidents. In contrast, Dorman (2000) insists that certain companies want to improve their public image by investing in safety, without focusing on enhancement of their working conditions and reduction of their injury and fatality trends. However, the aforementioned authors concur that significant losses occur and that those from injuries and fatalities are not negligible.

The current research is (a) focused on the difficulty of companies expressing the RCOs' benefits in monetary terms and (b) on the widespread phenomenon of companies underestimating safety investments (Brody et at., 1990; Kristensen, 2011). On this basis, the constant perception of companies compromising on safety (so as to reduce their annual budgetary expenses) is now combined with the lack of investment on RCOs (since RCOs are considered as an extravagant expense by ship-owners). Due to these obstacles, Jalon et al. (2011 a,b) believe that shipping companies reluctantly sustain their current RCOs without considering that it is important to further their safety performance.

According to Hollnagel's research (2014), using the "Sharp End, Blunt End Model", on the right side there are the barriers that make the shipping industry struggle. On the left side are the RCOs that safety managers and DPAs have used to deal with the aforementioned barriers, and in the middle of the sharp end is what is going through their minds. "*How do they make decisions related to these barriers, and how they decide which RCOs they are going to approve?"* Based on case studies, senior managers were asked to identify their barriers and their obstacles towards safety enhancement. On this basis, it was concluded that they had to trade off one goal for another to be met.

Shanahan's and Gregory's (2010) research has further shown that:

1. lack of administrative training,
2. absence of safety culture on the administrative side,
3. negligible investment on RCOs
4. or even recklessness in responding to commercial demands

are just a few of the obstacles that the shipping community is currently facing.

This concept has recently been challenged by Reese's (2011) studies, demonstrating that any kind of safety investment made by a company is indirectly triggered by the reduction of:

1. P&I premiums,
2. sick leave,
3. hospitalization,
4. lost man hours, and
5. fines from mitigation of workplace accidents.

However, half of Reese's studies failed to specify whether these incentives are having a serious effect on company profitability, leaving one to infer that they have not been treated with caution. This debate gained fresh prominence when Stopford (2013) argued that ship-owners are led to believe that any expenditures on preventive accident measures are 'extravagant', hence safety projects have been deemed as non-returnable investments (by them) that will not financially benefit the company itself. As ship-owners confront the reality of accidents on board ships, it is perhaps worthwhile to reflect "W*as our doubt really due to lack of evidence or merely lack of knowledge?*".

CHAPTER No4: ANALYSIS AND DISCUSSION OF COSTS OF INJURIES AND FATALITIES

4.1 Main Research Literature of this thesis

As illustrated in Figure 4, the literature review section (CHAPTER 4, 5) will be separated into five discrete stages. It is vitally important to provide, at stage 1 all the core definitions that this specific case study intends to explore, i.e. maritime injury, direct, indirect and unknown costs of injury, fatality, and RCOs, in order to keep the reader oriented within the boundaries of this project.

This will avoid any misapprehension of confusion in stages 2 and 3 since this thesis will gradually move to the identification and quantification of only the previously mentioned direct, indirect, unknown and employers' costs/expenses from injuries and fatalities as well as the costs/investment and the economic benefits of RCOs.

Finally, at stage 4, the literature review will furnish a thorough explanation of four RCOs that can be applied on Panamax and Aframax crude oil tankers: RCO1: Active steering gear redundancy, RCO 2: Navigational sonar, RCO 3: Hot work procedure training, RCO 4: Engine control room additional emergency exit.

This section will end by furnishing a critical analysis and discussion of the whole literature review.

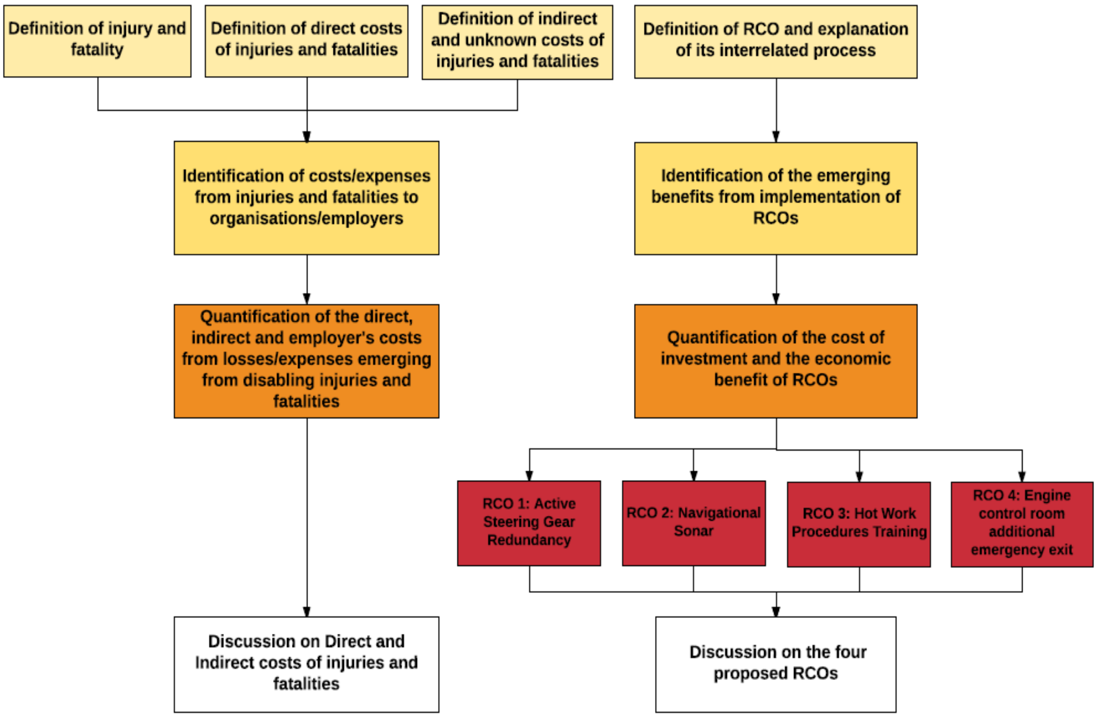


Figure 4: The analytical process of literature review

4.2 Definition of injury and fatality

In addition, the National Safety Council (NSC) (2015) presented the term **disabling injury** to refer to an accident that results in "some degree of permanent impairment, or renders the injured person unable to effectively perform his or her regular duties for a full day beyond the day of injury". According to OCIFM (1997), **temporary disability** is "a condition that temporarily disables the crewmember from working, while a complete recovery is anticipated", followed by **permanent total disability** and **permanent partial disability**. Finally, the definition of **fatality** was suggested as "a death directly resulting from a work injury regardless of the length of time between the injury and death" either to individuals or to a group of individuals.

For the purpose of this thesis, the term 'injury' will cover the disabling injuries leading temporary disability in three different sectors i.e. tug, passenger and tanker.

The terms *incident* and *accident* are clarified, for the purposes of this research, as follows: "An incident is an undesired event that downgrades the efficiency of a business operation. An accident is an undesired event that results in physical harm to a person" (Stranks, 2016). However, the current case study will utilize those terms interchangeably, focusing exclusively on the cost of maritime accidents, i.e. disabling injuries and fatalities in the maritime sector.

4.3 Definition of direct costs of injuries and fatalities

Maniati (2014) revealed that every company that chooses to invest in RCOs would be able to significantly shrink its safety related losses. On the contrary, in case of absence of safety investment, numerous costs will promptly emerge. DeMarco et al. (1997), are certain that as an immediate consequence of an incident, whether an injury or death, direct "insured" and indirect "uninsured" costs/losses will negatively influence the company. As a rebuttal to this point, Champ and Ornitz (2002) maintains the belief that direct costs are considerably easy to quantify and include insurance premiums, legal sanctions, medical and emergency response costs, property repair costs, workers' compensation, liability and litigation costs.

4.4 Definition of indirect and unknown costs of injuries and fatalities

According to Morrison (2017), safety managers are inclined to believe that once the insurance is paid, the company is financially safe since the insurance company will cover any accident costs. To their dissatisfaction, it has been revealed that **indirect** costs are 2-10 times higher than direct costs and will be paid by the corporate account rather than the insurance. These indirect costs generally include employer's cost, replacement costs associated with damaged equipment, supplementary time and administrative work, expressed in monetary value, as a result of productivity losses. Moreover, Reese (2011) demonstrated that (a) production disturbances, (b) decrease of company's competitiveness and (c) fees for legal services are major indirect costs that are generally forgotten by safety managers. Further clues can be found by examining Ferrett and Hughes' (2009) observations, which identified as indirect costs those associated with completing paperwork after an injury or fatality, the costs to replace an injured worker with a trained one and any unknown costs resulting from an incident.

Furthermore, Neumann and Weintrit (2013) act as the common denominator and revealed that a fatality is almost impossible to quantify in monetary terms and can ruin the success of the shipping company. With reference to the latter, this scientific endeavor reveals that the 'unknown costs' serve as a game changer, resulting in the discovery of morale and reputation as key costs of accidents. Moreover, a broader perspective has been adopted by Liaoming (2005) who argued that when a fatality occurs, a negative message is indirectly spread among employees, that "*the company does not really care us about us*". Although undetectable, 'public relations' damage is there and it impairs employees' morale as well as the quality of their work. The reputation is also impaired due to the negative evaluation of the shipping company by its crewmembers, owing to unsafe and unhealthy workplaces onboard. On the contrary, a company with low accident records is more likely to retain a large pool of qualified crew members and an underlying competitive advantage against others. Commenting on Liaoming (2005), Maniati (2014) concluded that "*the reputation of a company is a reflection of its public image and must be considered as an important factor influencing its success*".

4.5 Identification of costs/expenses from injuries and fatalities to organisations/employers

Initially, Neumann and Weintrit (2013) revealed that every time that an accident occurs, remuneration costs, as part of the disability payment, should be allocated from the employer to the disabled employee. This point of view was further supported by Morrison (2017), who asserted that additionally to the aforementioned expenses, the company generates further losses in an effort to hire another individual to cover the duties of the disabled one. With respect to the uninsured - indirect costs of the employer who is associated with injuries and fatalities, Ferrett and Hughes (2009) additionally outlined that insurance premiums constitute the annual payment of the ship-owners to the insurance companies in order to financially cover an event or failure. Additionally, Schumann and Schneid (2006) highlighted that production disturbance covers any unexpected procedure that an organization has to implement to preserve its level of output (e.g. employing temporary personnel). Maniati (2014) and Morrison (2017) further revealed that administrative costs cover the ship-owner's expenses to administer all the above costs, without excluding the legal costs imposed on the shipping company from exposing a vessel to a hazard. For example, Ferrett and Hughes (2009) indicated that the monetary value of the work time lost due to absenteeism of the injured person is not easy to quantify. On the contrary, it was exemplified by Neumann and Weintrit (2013) that the 'money versus time' spent on the investigation of the particular injury or fatality plays an immense part of the employer's indirect costs.

4.6 Quantification of the direct, indirect and employer's costs from losses/expenses emerging from disabling injuries and fatalities

This project now moves onto the subject of injuries, fatalities, and RCOs by furnishing their precise economic values.

With reference to the latter, the evidence furnished by Laporte and Barnhart (2007) initially suggested that the NSC's estimations of the economic losses deriving from a disabling injury or death are one of the most accurate. In fact, a number of researchers (Champ & Ornitz, 2002; Morrison, 2017) have reported that NSC's estimations incorporate the administrative costs, medical costs, employer's costs and the cost of wage and productivity losses, with respect to temporary disabling injury expenses. According to DeMarco et al. (1997), a disabling injury, (**including employer's costs**) accounted for $28.000 and a death for $790.000 in 1997, while NSC (2015) reveals that costs rose to $39.000 and $1.000.000, respectively in 2015.

There is also a consensus among multiple researchers (Leigh, Markowitz, Fahs, & Landrigan, 2003; McKinnon, 2007) who validated the NSC's value of approximately $28.000 as a reasonable approach regarding the average cost of a disabling injury. However, since DeMarco et al. (1997) wanted to expose more in-depth data, apart from a general rate of $28.000, they revealed, based on the ICF Kaiser Consulting Group's (ICF) observations, a standard index of $10.000 for direct costs, another index of $27.000 for indirect costs, which validate a globally accepted value of $37.000 as a whole for a disabling injury incident. ICF also performed a comprehensive study, separating the **average cost per disabling injury incident** into three different maritime sectors. The results of that correlational analysis are summarized in Table 4:

Table 4: Average direct cost per disabling injury incident

	Average cost per disabling injury incident ($)
Barge/ Tow/ Tug	28.840
Tanker	29.960
Passenger	37.800

Source: DeMarco et al., (1997)

In the same vein, by utilizing as a base the NCS's estimations and the relevant $790.000 basis per fatality, the ICF demonstrated the average **direct costs per death incident,** divided into three different maritime sectors, as shown in Table 5.

Table 5: Average direct cost per fatality incident

	Average cost per fatality incident ($)
Barge/ Tow/ Tug	829.500
Passenger	869.000
Tanker	1.240.300

Source: DeMarco et al., (1997)

Another objection coming from Champ and Ornitz, (2002) reflects recent scientific discoveries and corroborates that for every $1 allocated to direct injury costs, namely insurance or medical compensation, a supplementary $1-4 loss will emerge, allocated to indirect – hidden costs. Thus, when the interrelated costs are totalled, an average of $29.960 for injuries and $1.24 million per death incidents in tanker shipping industry will emerge **without including the indirect costs**.

From another point of view, it can be implied that the findings observed in DeMarco's et al. (1997) mirror those of Reese (2011). Although Reese's analysis did not take into account the indirect costs, his study examined the data as provided by the NSC in 2008, revealing that a serious non-disabling injury represents $22.674, a workplace disabling injury costs $48.000 and death costs $1.310.000. In order to avoid any misinterpretation, DeMarco et al. (1997) went one step further and provided two different methods for calculating the costs of disabling injuries as shown in Table 6. The right part of the table incorporates the employer costs, while the left table replaces it with a complete calculation of indirect costs, utilizing a 2.7 ratio between direct and indirect costs, giving a distinct illustration of the average expenses as an aggregate of all vessels. It was further presented by DeMarco et al. (1997) that if employers' costs are replaced with a complete estimation of indirect costs then an increase of average cost from $30.800 to $84.747 for injuries incidents and from $924.300 to $2.543.225 will emerge.

Table 6: Distribution of average disabling injury and fatality costs by applying indirect or employer's costs ($)

	Vessels' total				
	Average cost per disabling injury incident ($)	Average cost per fatality incident ($)		Average cost per disabling injury incident ($)	Average cost per fatality incident ($)
Wage and productivity losses	15.947	478.555	Wage and productivity losses	15.947	478.555
Medical Expenses	5.120	153.650	Medical Expenses	5.120	153.650
Administrative expenses	6.800	204.066	Administrative expenses	6.800	204.066
Employer costs	2.933	88.029	Indirect costs	56.880	1.706.954
Total	30.800	924.300	Total	84.747	2.543.225

Source: DeMarco et al., (1997)

Additionally, post hoc analysis performed by Morrison (2017) detailed that if $1 of direct costs is equivalent to $2.12 for indirect costs, then a single fatal workplace incident of $1.42 million will cost $3 million in total due to the indirect added costs. Hence, it can be implied that there is a direct monetary correlation between Morrison (2017) and Table 6 that DeMarco et al. created in 1997, revealing the comprehensive breakdown of costs pertaining to disabling injuries and deaths in three different maritime sectors. Together these results defy everything that is known about the costs of the three maritime sectors. There are, however, distinct dissimilarities between the different maritime sectors (tanker, passenger, barge/tow/tug) if indirect costs are also included as can be seen from Table 7.

Table 7: Distribution of disabling injury and fatality costs on three different maritime sectors incorporating indirect costs

		Vessels' Average Costs		
	Cost Category	Costs for tankers in $	costs for passenger in $	costs for Barge/ Tow/Tug in $
Injuries	Wage and productivity losses	15.512	19.571	14.932
	Medical expenses	4.980	6.284	4.794
	Administrative expenses	6.615	8.345	6.367
	Indirect costs	55.329	69.807	53.260
	Total	82.436	104.007	79.354
Deaths	Wage and productivity losses	642.164	449.924	429.473
	Medical expenses	206.180	144.457	137.891
	Administrative expenses	273.832	191.857	183.136
	Indirect costs	2.290.528	1.604.829	1.531.882
	Total	3.412.704	2.391.087	2.282.382

Source: DeMarco et al., (1997)

4.7 Discussion on Direct and Indirect costs of injuries and fatalities

This project performed a comparison between DeMarco et al. (1997) and NSC (2015) and revealed that the cost of an average disabling injury (including employer's costs) has increased by 39.28% from $28.000 to $39.000, while a fatality incident increased by 26.58% from $790.000 to $1.000.000 within an 18 year period.

Additionally, from Table 6, from DeMarco et al.'s (1997) investigation, it can be clearly seen that:

1. there is an increase of $53.947 for disabling injuries when employer's costs and shifted with a complete estimation of indirect costs (from $30.800 to $84.747),
2. there is an increase of $1.618.925 for fatalities (from $924.300 to $2.543.225), and

3. that such a difference, which is attributed to the "weight" of the cost category, seems relatively unchallenged.

However, past records of costs, do not necessarily correspond to the evolution of maritime knowledge because no one can observe the incremental analysis of accident costs which, in fact, suggests a gap in knowledge. In order to determine the differences among employer's costs versus indirect costs, the indirect costs of injuries shown in Table 6 are converted into percentages, and presented in Table 8.

Table 8: Difference of percentage analysis by applying indirect costs or employer's costs on injuries and fatalities

Wage and productivity losses	51,78%	Wage and productivity losses	18,82%
Medical Expenses	16,62%	Medical Expenses	6,04%
Administrative Expenses	22,08%	Administrative Expenses	8,02%
Employer costs	9,52%	Indirect costs	67,12%
Total	100%	Total costs	100%

Surprisingly, the data yielded from this approach uncovers:

1. a definite proof that DeMarco et al. (1997) is in direct correlation with Champ and Ornitz, (2002) and Leigh et al. (2003), while
2. the percentage analysis in Table 8 reveals a low of 9,52% for employer's costs and a high of 51,78% for wage and productivity losses.

By contrast, when employer's costs are shifted by a complete estimation of indirect costs:

1. indirect costs peak at 67,12% of costs for injuries and fatalities,
2. verifying the heavy burden of indirect costs, and
3. the $1 to $4 approximate ratio between direct and indirect costs as Champ and Ornitz, (2002) previously stated.

It is also encouraging to analyze Table 7 because:

1. The average costs of injuries on passenger vessels are $24.653 higher than barge/tow/tug vessels and $21.500 higher than tanker vessels.
2. On the contrary, when fatalities are the subject under discussion, tanker fatalities are significantly higher compared to the others; they are $1.130.322 higher than barge/tow/ tug vessels, and $1.021.617 higher passengers vessels.
3. It is evident that even if disabling injuries on passenger vessels are the most expensive among the three different sectors, tanker vessels are taking the lead when fatalities is the area under discussion.

CHAPTER 5: ANALYSIS AND DISCUSSION OF RCOs

5.1 Definition of RCO and explanation of its interrelated process

Ericson (2016) explained that an RCO encompasses (a) the precise action that will intentionally be performed in an effort to mitigate any potential of being exposed to a hazard, or (b) the action that removes the hazard or (c) minimizes any likelihood of being exposed to that hazard. Besides Ericson, Banerjee (2002) insisted that investments in RCOs are performed in an effort to enhance the safety of seafarers and protect them from injuries and fatalities. From this perspective, the hazard, defined as the condition is the main source that is directed against a target with a potential of threatening or harming it. In this project, the analysed hazards will be collisions, groundings, fires, and explosions.

In an effort to facilitate the IMO decisions, the IMO developed the FSA framework as a way of identifying hazards, analyzing risks, identifying and evaluating RCOs, performing cost-benefit analyses and presenting proposals by ranking RCOs based on their cost-effectiveness (MSC 83/INF.2, 2007). According to Rausand, (2013) whenever the economic benefit of an RCO is more than the sum of its initial investment and its annual maintenance costs, then that RCO is considered as cost-effective. In order to execute a cost-benefit analysis on the proposed RCOs, the FSA guidelines proposed the 'Cost of Averting a Fatality' (CAF) criterion.
According to MEPC (58/INF.2) (2008), "the relation between the costs of implementing an RCO and the percentage of risk reduction is calculated and

compared to a CAF threshold of 3.000.000$". In an effort to reveal the cost-benefit objective of a cost-benefit analysis and name the RCO as 'cost effective', the potential researcher has to prove that the chosen RCO preserves the aforementioned relation at less than the CAF threshold. Likewise, it can be said that the implementation costs are less compared to the extracted benefit gained from the introduction of that RCO over the lifetime of the tanker i.e. 25 years. In order to predict the level of the cost effectiveness of multiple RCOs, a sensitivity analysis shall also be implemented. Garbatov and Soares (2015) revealed that, as part of FSA, the following equations quantify the achieved risk reduction in monetary terms:

Net cost of averting a fatality

$$NCAF = \frac{\Delta C - \Delta B}{\Delta R_S}$$

Gross cost of averting a fatality

$$GCAF = \frac{\Delta C}{\Delta R_S}$$

"**ΔC** is the cost of RCO per ship during the lifetime of the vessel
ΔB is the economic benefit per ship resulting from the implementation of the RCO during the lifetime of the vessel, being environmental and property benefit
ΔR is the risk reduction per ship, in terms of number of fatalities averted (ΔRs), implied by the RCO during the lifetime of a vessel". (Garbatov & Soares, 2015)

MEPC (2008) suggested that in order to reveal the NCAF and GCAF, Net Present Value (NPV) calculations shall be performed to expose the RCO's costs or its economic benefits over a ship's lifetime using the following equation:

Net Present Value

$$NPV = A + \frac{X}{(1+r)} + \frac{X}{(1+r)^2} + \frac{X}{(1+r)^3} + \ldots + \frac{X}{(1+r)^T} = A + \sum_{t=1}^{T} \frac{X}{(1+r)^t}$$

“**X** = Cost or benefit of RCO for any given year

A= Amount spent initially for implementation of RCO

r = Discount rate

T = 25 (years)

A uniform discount rate of 5% will be used in this case study, based on the ‘real’ above the inflation risk free rate of return i.e. 3% inflation and 8% depreciation)”. MEPC (2008)

5.2 Identification of the emerging benefits from implementation of RCOs

Based on a previous investigation, it has been proved that by marketing companies’ safety commitment, a core benefit is gained by tanker shipping companies in terms of attracting new charterers and retain existing ones (Polyzois, 2015). Supporters of this view (Aviva, 2011; Maniati, 2014) not only agreed that safety investment further contributed to a company’s marketability but also considered the maximization of the company’s profit (generated from idle investments) as the key benefit of investing in RCOs. Rosenthal, Kleindorfer, and Elliott (2006) pointed out that any benefit to a company’s safety reputation is an imminent consequence of its transparency and profound corporate responsibility. However, such a core benefit of RCOs towards preventing injuries and fatalities could not be identified in Cecich’s (2005) analysis. Instead, he held the view that companies shall not direct all their investments towards saving money or reducing corporate expenses. Instead, investments shall be proposed in such way that will reduce onboard maritime accidents. In an effort to validate this point of view, Behm (2004) concluded that nonfinancial benefits encompass increased productivity and reputation, improved employee well-being, enhanced image in the public and the media and engaged workforce. Based on their research, it was proved that it would be a grave error for ship-owners to neglect that any reduction of inherent risks indirectly tends to increase shareholders’ value.

In support of the aforementioned source, Bottani, Monica, and Vignali (2009) demonstrated that any organization that achieves a low rate of injury could embrace a lower insurance premium and avoid media intervention due to its high safety performance.

Benefits proved to vary according to the size of the organization. Such a distinction was exemplified in Celik's (2009) case study, which confirmed that in relatively large organizations reputation will improve, the trademark will gain ground and the image of the enterprise will be indisputably enhanced. In support of this view, Dorman (2000) claimed that the organization's commitment towards Corporate Social Responsibility would be revealed, resulting in the reinforcement of its power within the worldwide market. Overall, these cases support the view that reassurance, promotion of investor's confidence and positive engagement of stakeholders in company's activities will be enhanced.

In smaller organizations, the benefits are looked at from a different scope. Recent cases reported by Oxenburg and Marlow (2005) also support the hypothesis that benefits are focused on preserving an affordable level of insurance, avoiding the loss of key personnel and business's disruption, motivating and retaining staff commitment with the ultimate aim of winning new and retaining old charterers.

5.3 Quantification of the cost of investment and the economic benefit of RCOs

In this section, safety investments from individual companies will be analysed in order to distinguish the necessary amount of money to ensure a safety improvement along with the interrelated benefits that will emerge as a consequence of the implementation of a safety program.

Champ and Ornitz (2002) claimed that Anglo-Eastern Ship Mgt. Ltd implemented a considerable safety investment in 2000 of $300.000 to establish a safety program by adding $250.000 to its annual budget. Additionally, the company earmarked $10.000 for bulk carriers and $20.000 for tankers for seafarer training, and $30.000 to $50.000 was invested per annum for the robust educational support of its interdepartmental staff on shore.

Finally, 2.5% of the company's total annual budget, which is equivalent to $15.000 to $30.000/month per vessel, was allocated for quality assurance mechanisms such as ship's equipment, communications, and audit fees. Surprisingly, as a result of this investment Anglo- Eastern has:

- improved employee retention by 10%
- reduced damage to vessels equipment by 19%
- grew by 28% in vessels under management
- reduced its loss of man-hours by 35%
- decreased, by 76%, the off-hire time and hours wasted in port or at sea as a consequence of breakdowns and accidents, and
- managed to maintain zero fatal incidents for four consecutive years.

According to this case, these definitive results suggest that there is a direct association between safety investment and the emergence of numerous benefits.

Further statistical analysis performed by DeMarco et al. (1997) suggests a 25-35% reduction of loss of man hours as one of the core benefits emerging from the implementation of RCOs. According to their conclusions, exposing the core economic benefits of RCOs as a percentage analysis, are shown in Table 9. As of these data, a positive correlation between Champ and Ornitz's (2002) true figures and the past observations of DeMarco et al. (1997) was confirmed with regard to RCOs and the reduction of companies' expenses.

Table 9: Emerging benefits resulting from investing on RCOs

reduction of P&I premiums	6-10%
reduction of comprehensive premiums	10-15%
reduction of hospital hours	15-25%
reduction of loss of man-hours	25-35%
reduction of environmental pollution fines	30-40%
reduction of sick-leave	35-45%
reduction of cargo damage	50-90%

Source: DeMarco et al., (1997)

With reference to the latter, Angello (2010) and Bunn, and Pikelny, Slavin, and Paralkar (2001) theorize that companies are able to reduce their personal injury pay-outs by 70% after 3 years from the establishment of a risk prevention measure.

5.4 A comprehensive explanation of four RCOs designed for Panamax and Aframax crude oil tankers

This section will furnish four different RCOs that can be directly applied on Panamax and Aframax crude oil tankers, while the discussion section at the end of this project will critically analyze them in an effort to identify their individual cost-effectiveness. The chosen RCOs were initially eight, but after close consideration, only four of them were explored, excluding ship design modifications, terminal speed sensors, hull stress and fatigue monitoring systems and double sheeted low-pressure fuel pipes. Since this project is focused on how to enhance the proactive standpoint of safety-risk managers, the previously mentioned four RCOs will not be analysed. That is because these are out of the scope of this study and are more relevant to individuals with a substantial marine engineering and technical background that differs from that of safety managers with previous experience as a captain on crude oil tankers.

The four proposed RCOs, which come from the FSA study MEPC 58/INF.2 (2008), are of major importance because this project will utilize them in order to extract its key conclusions. MEPC 58/INF.2 (2008) is the most recent document specializing exclusively on Aframax and Panamax crude oil tankers. From an academic point of view, this project will avoid subjectivity by maintaining an objective manner throughout the project since the validity of the conclusions will be affected by it.

FSA experts from MSC 91/WP.6 (2012) performed a critical review of MEPC 58/INF.2 (2008) and revealed that:

1. the expertise of FSA participants was adequate and no deficiencies were identified that may affect the FSA results, and
2. that MEPC 58/INF.2 FSA study (2008) was performed according to the FSA Guidelines.

Concerning the validity of the FSA data, it has been pinpointed that the data sources for the FSA may lack data or contain errors. That is why FSA experts shall carefully collect their data. On the contrary, it was stated that the MEPC 58/INF.2 did not include a sensitivity analysis as required in paragraph 6.2.3 of the revised Guidelines (MSC-MEPC.2/Circ.12, 2013). Such an analysis is a crucial risk assessment tool to assess recommended RCOs, particularly during high uncertainty scenarios.

The first RCO, Active steering gear redundancy, was chosen because, according to MSC 91/WP.6 (2012), Safety Of Life At Sea (SOLAS) regulation II-1/29.14 comprises the requirements of redundancy of power supply to the steering gear.

The second RCO, navigational sonar, was chosen because it maintains a negative NCAF; thus, it was agreed to propose to the IMO Committee that the Ship Design and Equipment Sub-Committee should also take into account this RCO.

The third RCO, Hot works procedures training, was chosen because the individual GCAF of this RCO was proved to be small by the MEPC 58/INF.2 FSA study, while its NCAF was found to represent a negative value. On this basis, MSC 91/WP.6 (2012) experts agreed to propose to the IMO Committee that the Fire Protection (FP) Sub-Committees shall consider this RCO as applicable to every crude oil tanker vessel.

The forth RCO, Engine control room additional emergency exit, was chosen because the FP IMO Sub-Committee (2013) has already listed this RCO under agenda items on "Development of requirements for additional means of escape from machinery spaces", which includes any secondary means of escape route from enclosed spaces within machinery spaces.

RCO 1: Active Steering Gear Redundancy

The first RCO is proposed by MEPC (58/INF.2, 2008) to automatically change the steering gear pump in the steering gear system and mitigate the groundings or collisions originating from system's failure. Det Norske Veritas (DNV) Fire Safety experts (Appendix 13) detected that only one steering gear pump can operate while the tanker is navigating in open waters compared to two steering gear pumps in narrow waters. In narrow waters, in the case of electrical failure in the pump, the second pump will already be in operation and sufficiently maintain the ship's steering. Irrespective of the officer of watch who is alerted by an audio and visual alarm to switch on the second pump in case of electric failure of the first one in open waters, this RCO intends to limit the possibility of human error as well as the reaction time. Thus, this RCO will provide benefit by reducing the vessel's risk only at open sea. DNV experts revealed that the automatic changeover of steering pumps will reduce the risk of grounding (leading to fatalities) by 10%. By utilizing the collision event tree (Appendix 8), it is clear that there is an absence of fatality risk during striking events. Thus, no risk reduction can be implemented. However, by utilizing the grounding event tree (Appendix 9), computations reveal that one life every 208.000 ship-years, 1.2E-04 over the 25 year lifetime of a tanker or 4.8E-06 lives per ship year will be saved. Furthermore, an initial investment of $2.000 and an annual repair cost of $200 result in a Net Present Value (NPV) of $4.800 for the 25 years of a tanker's lifetime.

The economic benefit will emerge through the introduction of this RCO by mitigating groundings that lead to fatalities. Irrespective of the low cost of installation and maintenance, the risk of fatality is not expected to be decreased significantly due to the $40 million of the GCAF, which is notably greater compared to the $3 million per life saved according to IMO recommendations (MSC - MEPC .2/Circ 5, 2006). Due to the reduced oil spills, this RCO results in an economic benefit of $37.800 per ship year and a reduction of property damage that results in an economic benefit of $1.630 per ship year. Finally, these costs are expected to result in a figure of -$4.377.000.000 in the NCAF calculation.

RCO 2: Navigational Sonar

It is also believed by MEPC (58/INF.2, 2008) that large tankers, such as an Aframax, are in high necessity of a navigational sonar system because it can identify a grounding hazard. Industry representatives concluded that an initial investment of $150.000 for a navigational sonar of 0.5 nautical miles seems logical. Apart from the initial purchase cost, an annual investment of $1.500 is required for repairs and spares along with $10.000 every five years for maintenance, which will be performed at dry dock. The NPV represents a value of $196.650 over the 25 year period of a tanker's lifetime. During the process of investigating this RCO, multiple potential avenues of information were engaged in an effort to obtain data. DNV experts (Appendix 13) revealed that a risk reduction of 15% is proposed to emerge in conjunction with fatal events. According to the grounding Event Tree calculations (Appendix 9), this RCO is anticipated to save one life every 51.000 ship-years, 4.9E-04 over the 25 years or 2.0E-05 lives per ship year. It has to be mentioned, though, that RCO's economic benefit is the mitigation in groundings rates (resulting in fatalities).

Irrespective of the low installation and maintenance costs, the risk of fatality is not expected to be decreased significantly due to the $461 million for GCAF, which is notably greater compared to the $3 million per life saved according to IMO recommendations (MSC - MEPC .2/Circ 5) (2006, b). Due to the reduced oil spills resulting in an economic benefit of $167.379 per ship year along with the reduction of property damages resulting to an economic benefit of $1.630 per ship year, these costs are expected to result in a figure of -$4.417.000 in the NCAF calculation.

RCO 3: Hot Work Procedure Training

According to MEPC (58/INF.2, 2008), hot work procedure training can be applied as an efficient RCO under the guidelines set out by International Safety Guide for Oil Tankers and Terminals (ISGOTT) (2006) and Oil Companies International Marine Forum (OCIMF) (1997). Crude oil tankers will pass vetting inspections under the Ship Inspection Report (SIRE) (2007) as a way to demonstrate that the chartered Panamax or Aftamax tankers are abiding by the international requirements. On an international standard basis, hot work procedure training shall be carried out two times per year to experienced and suitably qualified individuals. By utilizing the fire and explosion event trees (Appendices 10, 11) as well as DNV Fire Safety research (2001), it was revealed that a 43% risk-reduction is expected to emerge pertaining to fatalities originating from fires and explosions (if hot work procedure training is applied to experienced and suitably qualified individuals). In the case of implementing this RCO, one life per 1.280 ship-years or 1.9E-02 over the lifetime of a tanker or 7.8E-04 lives per ship-year will be saved by taking ship's lifetime as 25 years. The cost of a "one day" hot-work procedure training of all crew members engaged in hot-work duties performed proportionate to ISGOTT's level (International Chamber of Shipping, Oil Companies International Marine Forum and International Association of Ports and Harbours, 2006), is approximately $1.000/tanker. As per oil major vetting requirements of training two times per year, every tanker shall spend $2.000 per year, or total costs are Δc = $28.000 per tanker's lifetime, taking into consideration the NPV. It is further suggested that by reducing fires and explosions leading to fatalities, the economic benefit of embracing hot-work procedure training under SIRE's criteria will be revealed. The GCAF of applying hot-work procedure training, including NPV at five percent, is calculated at $1.450.000/per life saved. This figure corresponds to less than fifty per cent of the proposed criterion of $3.000.000 of IMO and reveals an NCAF of -$111.000.000.

RCO 4: Engine control room additional emergency exit

Machinery space, at a bare minimum, shall be equipped with two means of escape so as to come in agreement with Chapter II-2, Part D, Reg. 13 of the SOLAS Convention (2006, a). As far as the Engine Control Room (E.C.R) is concerned, these two ways of escape belong to the Engine Room (E.R) itself, excluding any other section of the vessel. According to MEPC 58/INF.2 (2008), by summing all crisis events like collision, grounding, fire, explosion and Non-Accidental Structural Failure (NASF) event trees (Appendices 8, 9, 10, 11, 12), the crew members may be trapped in the E.C.R or need an alternative way to escape through it. The RCO of installing an extra emergency exit connecting the E.C.R to the main deck without passing through the E.R is proposed. The risk of fatality was determined, contemplating that 30% of the day the E.R will be manned by at least one crewmember, taking into consideration the safety procedures for unmanned machinery spaces as well as crewmembers from the safe manning certificate. With the use of event trees, experts from DNV (Appendix 13) revealed that a risk reduction of 21% shall be expected by this RCO with respect to fatalities in case of emergency situation. This RCO is expected to save one life every 5.700 ship-years, 4.4E-03 lives over a 25 year period or 1.7E-04 lives per ship-year. Labor costs, A60 insulation, extra steel, door, and ladder equals to $13.840 for an extra emergency escape to be installed through the E.C.R and also used in NPV calculations. No maintenance costs are necessitated since this RCO is a structural addition. Thus, its economic benefits are estimated through the reduction of fatalities as a result of sinking and fire incidents from explosion, grounding and collision mishaps. The GCAF for this RCO was calculated at $3.170.000 which is 5% over the $3.000.000 per life recognized criterion of IMO's (2006). Since this RCO is only utilized as a tool of E.R escape, there is no potential loss of cargo (PLC) or potential loss of property (PLP), and, as a result, NCAF is the same as the GCAF.

5.5 Discussion on the four proposed RCOs

One of the questions in this study sought to determine the interrelated costs of RCOs. Thus, by combining RCO 1, 2, 3 and 4 in the literature review, multiple observations can emerge. It has previously been concluded by MEPC (2008) that when GCAF rates are lower than $3.000.000 then the proposed RCOs should be forwarded for implementation according to IMO criteria. Surprisingly, according to Table 10, it was found that RCO 3 and 4 maintain significantly low GCAF rates and, as a result, they can be deemed as cost-effective in comparison to RCO 1 and RCO 2. Furthermore, this project corroborates the theory that the yearly cost of maintaining RCO 3 is insignificant in comparison to the operational costs of managing a large Panamax or Aframax tanker. Besides, only RCO 3 reduces the risk up to a high of 43% with regard to potential lives lost compared to the other three proposed RCOs.

Table 10: Distribution of four selected RCOs of this project for Panamax and Aframax crude oil tankers

	Risk reduction ΔRs	Cost Δc	Benefit ΔB	$GCAF=\frac{\Delta C}{\Delta R_S}$	$NCAF=\frac{\Delta C-\Delta B}{\Delta R_S}$
	of saved lives	$	$	$	$
RCO 1: Active Steering Gear Redundancy	1.2E-04	4.800	538.000	40.000.000	-4.377.000.000
RCO 2: Navigational Sonar	4.9E-04	196.500	2.361.000	461.000.000	-4.417.000.000
RCO 3: Hot work procedure training	1.9E-02	28.000	2.200.000	1.450.000	-111.000.000
RCO 4: Engine control room additional emergency exit	4.4E-02	13.840	N/A	3.170.000	3.170.000

On the contrary, in an effort to assess the benefits of every RCO on a worldwide scale, the NCAF rates shall be taken into consideration, including the economic benefit of reduced PLC and PLP. An RCO can equally be named as cost-effective in the case that the NCAF represents a lower value compared to the $3.000.000 IMO threshold or is negative. A negative NCAF verifies that:

1. there is a general benefit, and
2. the economic benefit is more than the costs related to that RCO.

Beside, a large and negative NCAF will not rank the RCO above other RCOs or rank it as the most efficient compared to other RCOs. It has to be noted that this will result when its benefits maintain a higher value than its costs or when that RCO represents a potentially small risk-reduction figure (ΔR), meaning the smaller the risk reduction, the bigger the NCAF (Garbatov & Soares, 2015).

One of the most thought provoking aspects of this chapter is the claim that NCAF of RCO 1, 2 with negative values, represent RCOs that are economically beneficial in relation to oil-spill reduction as well as property damage. Even if their implementation costs are lower compared to the economic benefit of applying them, they are not economically beneficial in relation to how many lives will be saved. Even more compelling evidence revealed proof that NCAF of RCO 4 maintains an identical rate to the GCAF because this RCO is used for escape purposes only, with a value of 5% over the $3.000.000 IMO threshold.

CHAPTER 6: RESULTS OF INTERVIEWS

6. Demographics table

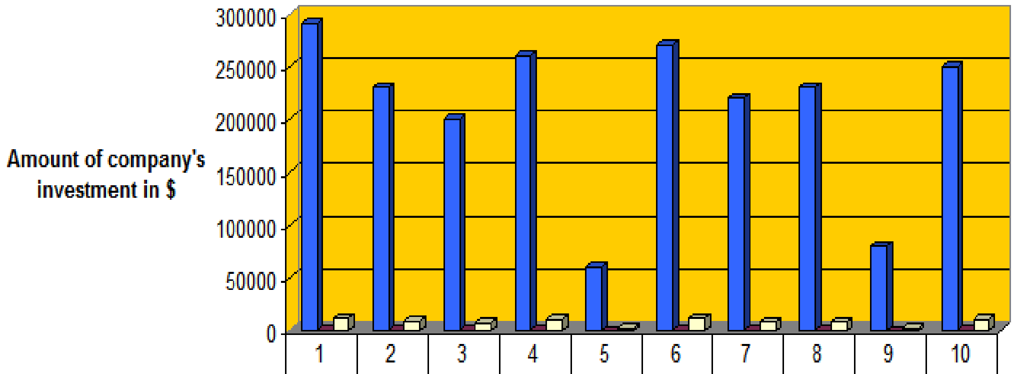
As inferred from the demographics, shown in Table 11, interviewees range vary between 34 and 58 years old, with all of them to having previously served on board as seafarers up to captain's rank. Their experience of participants on board ranged between 5 and 8 years on crude oil tankers. The interview subjects consist of eight currently active DPAs managing Aframax tankers and 2 safety managers handling Panamax tankers of 750.000-1.000.000 and 1.500.000-6.000.000 tons of total crude oil carrying capacity, respectively, and with shore based experience ranging between 2 and 18 years. The companies that took part in this investigation maintain a fleet varying from 15 to 60 crude oil tankers and a pool of 225 and 900 seafarers on senior management levels. Only the 8 Aframax companies annually train 225 and 900 on senior management levels (Master, Chief officer, 2nd officer, Chief Engineer, 2nd Engineer, 3rd Engineer) while the 2 Panamax companies do not train any of their seafarers.

Table 11: Response aggregation of questions from demographics table

		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
1)	How old are you? (Age in years)	58	48	49	55	35	55	49	45	34	50
2)	Have you served on board as captain?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
3)	If you have served onboard, how many years of experience do you have at sea?	8	6	6	6	5	8	6	6	5	7
4)	Please indicate your current position	DPA	DPA	DPA	DPA	safety manager	DPA	DPA	DPA	safety manager	DPA
5)	Experience in the field at the shore? For how long have you held this position?	18	10	7	7	2	15	10	9	4	15
6)	How many vessels does your company have?	60	50	15	45	15	56	41	42	20	55
7)	How many seafarers from the senior management levels on board are recruited at your company? (Master, chief officer, 2nd officer, Chief Engineer, 2nd Engineer, 3rd Engineer)	900	750	225	675	225	840	615	675	300	825
8)	How many seafarers from the senior management levels on board does your company train?	900	750	225	675	0	840	615	675	0	825
9)	What is approximately the total carrying capacity of your crude oil tankers in tons?	6.000.000	5.000.000	1.500.000	4.500.000	750.000	5.600.000	4.100.000	4.500.000	1.000.000	5.500.000
10)	What kind of crude oil carriers does your company have?	Aframax	Aframax	Aframax	Aframax	Panamax	Aframax	Aframax	Aframax	Panamax	Aframax

6.1 Interview question No1 "From a financial point of view, which are the emerging expenses for the establishment of an accident prevention program?"

As illustrated in Figure 5, four DPAs (P1, P4, P6, P10) clearly stated that an initial investment of $290.000 - 250.000 seems prudent to be allocated in order to make a notable difference towards risk prevention. Along the same lines, four out of ten participants (P2, P3, P7, P8) stated that in order to mitigate their company's injury trends and preserve a zero fatality rate, an initial amount of $230.000 - 200.000 is imperative. On the other hand, P5 and P9, the two safety managers of the interview process believe that there is no need to proceed with an initial investment exceeding $60.000 to 80.000, especially during crisis periods.



	1	2	3	4	5	6	7	8	9	10
Initial investment	290000	230000	200000	260000	60000	270000	220000	230000	80000	250000
Training of each seafarer per year	350	300	200	290	0	260	300	280	0	200
Safety equipment per vessel per year	12000	9000	8200	11500	3000	11800	8500	8500	3100	11500

Distribution of investments per applicant's company

Figure 5: Response aggregation of Interview question No1- Distribution of amount and categories of safety investment

Furthermore, four DPAs (P1, P4, P6, P10) insisted that $11.500 - 12.000/year per vessel for safety equipment is imperative so as to mitigate the loss time injury trends. A different view, as stated by four DPAs (P2, P3, P7, P8), that flew in a contrary direction from the rest of the respondents was that they needed, as a bare minimum, $8.200 -9.000/year to limit their Lost Time Injury frequency Rate (LTIR), while P5 and P9 disclosed that their companies' notions to limit safety expenditures, resulted in limited annual safety budgets of just $3.000 - 3.100 per vessel for safety related equipment in an aim to indirectly increase their future investments.

From another point of view, P1 vocalized that seafarers that hold top ranks on their tankers are annually trained on fire prevention programs at an expense of $350/year. What is interesting in this data is that by following the same pattern of behavior, five DPAs (P2, P4, P6, P7, P8) affirmed that professional seafarers are trained at $280 - 300/year. A smaller number of those interviewed (P3, P10) suggested that their company spend $200/year per person on fire-fighting and safety related programs.

However, the first response of two safety managers (P5, P9) was that it was not their responsibility to train seafarers since they had enough training from the Government. One of them (P5) exemplified by stating a few direct quotes that a manager had voiced in a meeting "*I will not spend more money so as to train them and then flee educated to another company*".

These results indicate numerous reasons for an in-depth safety analysis. Thus, the next chapter moves on to discuss the benefits of investing in RCOs in a tanker shipping company.

6.2 Interview question No2 "Based on your professional experience, which are the benefits of investing in RCOs in your company?"

In response to this question, as depicted in Figure 6, the overwhelming majority of respondents emphasized the reduction of P&I premiums as the most significant indirect impact gained from investing in RCOs. Along the same line of reasoning, minimal injury and fatality incidents are considered to be almost equivalent in value, with only P5 neglecting to mention this benefit. Furthermore, as inferred from the inquiry, six out of ten interviewees (P1, P2, P4, P6, P7, P10) unambiguously stated that companies that invest in RCOs annually decrease the off-hire time of their fleet. Interestingly, new charterers will be attracted and old ones will be retained, as articulated by seven interviewees. It is interesting to note P1's statement, which elaborated that "*charterers have shown a marked preference for safe and innovative fleets*".

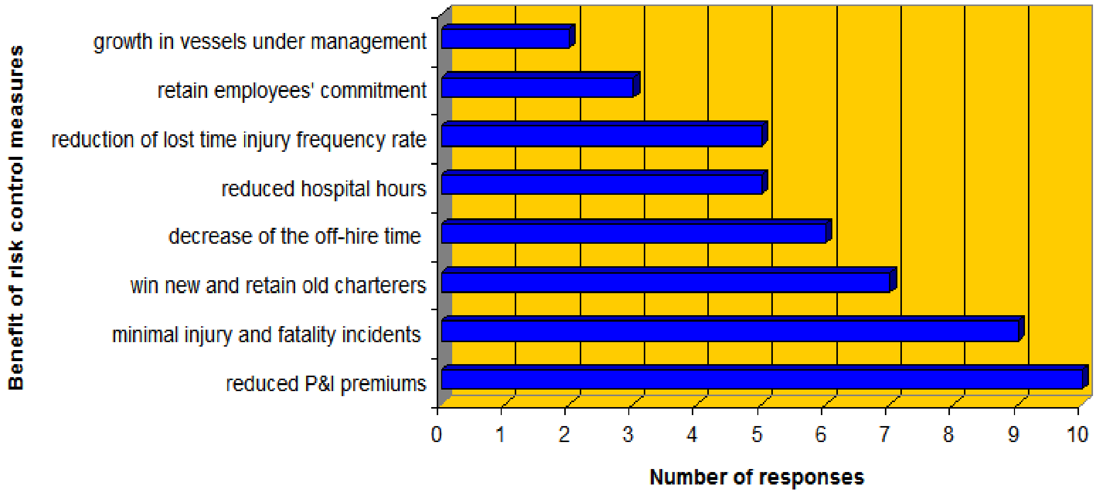


Figure 6: Response aggregation of Interview question No2- Benefits of investing on RCOs

In addition, five out of ten respondents (P2, P4, P6, P8, P10) affirmed that tanker-companies with RCOs in place have reduced their seafarers' hospital hours due to the reduction of hazards. Likewise, five DPAs (P1, P4, P7, P8, P10) revealed one more impact as the reduction of LTIR. On this, three managers (P1, P4, P8) acknowledged that RCOs safeguard the seafarers to return to their next scheduled shift while one of them (P8) exemplified by saying that "ROCs reduce slips, trips and falls and, as an imminent consequence, LTIR".

A small number of responses, three out of ten, leaned toward concomitant benefits of RCOs. As P1, P6 and P10 strenuously expressed that RCOs retain employees' commitment since high-potential employees are engaged to companies that maintain a high safety performance level. Two of them (P1, P10) added that by improving the safety of the people on board, you retain your shore side personnel and you improve the viability of the organization itself.

Finally, P5 and P9 referred to the growth of the company's fleet as a secondary benefit originating from such a safety establishment. In making an attempt to solidify this claim, one of them (P5) articulated that "*an RCO could stimulate the emergence of a new fleet even among prolonged recession periods*".

6.3 Interview question No3 "According to your professional experience, are there any barriers that restrict the investments on RCOs?"

Based on the results of the correlational analysis, as summarized in Figure 7, nine out of ten respondents stated the lack of proactive vision as the top obstacle towards investing in RCOs. In addition to this statement, one of them (P10) added that "*there is no underlining reason to remain as an idle observer when fatalities still occur"…"sadly, a large portion of managers still remain inactive*". Another one (P2) also affirmed that "*senior managers and ship-owners shall foresee potential obstacles and not just passively observe injuries to pass in front of them*".

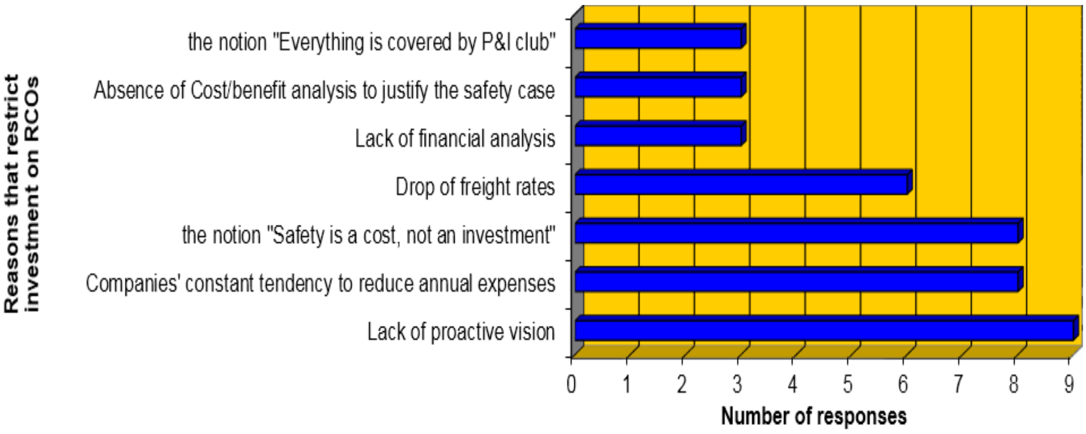


Figure 7: Response aggregation of Interview question No3- Barriers that restrict investment on RCOs

Further analysis showed that companies' tendencies to reduce annual expenses serves as another hindrance to the mitigation of injuries and fatalities, as eight of them (P1, P2, P3, P4, P6, P7, P8, P10) stated. P1 (a DPA of 58 years old) further disclosed that "*intense desire for more profit leads ship-owners to commit unlawful* *acts"*. P3 and P4 stated that stockpiling wealth by reducing ship's safety equipment is not a prudent way to manage company capital. Along the same lines, it was disclosed that the massive financial meltdown of 2008 considerably shifted the ship-owners' positively oriented safety norms towards less prudent ones.

Additionally, six out of ten participants advocated that the drop in freight rates is indeed a hindrance to safety investments, especially during the current recession period.

An equal argument among eight interviewees was that investment in RCOs is mainly considered as a cost and not as an investment, restricting investment in RCOs. Besides, no significant differences existed between the aforementioned answer and respondent (P5) who stated that "*the return on investment is insignificant to make safety a priority*".

Moreover, three of the respondents (P1, P6, P10) believe that the notion '*everything is covered by the P&I club*' hampers the mitigation of injuries and fatalities. Taken together, three DPAs (P1, P4, P6) expressed the belief that there is a lack of financial analysis starting from corporate management itself, while three of the participants (P1, P6, P10) additionally declared that the absence of cost/benefit analysis to justify the safety case to higher management indirectly hampers the mitigation of maritime related accidents.

6.4 Interview question No4 "When there is an injury or fatality incident in your company, what do you think is the cost that the employer is exposed to?"

In response to this question, as depicted in Figure 8, 9 a range of responses was elicited. Five DPAs (P1, P2, P4, P6, P10) stressed damage to the company's reputation as the utmost indirect impact from the occurrence of injuries and fatalities.

As inferred from the inquiry, seven respondents (P2, P3, P4, P5, P7, P8, P9) unambiguously stated that everything is paid by the P&I club, while three of them (P3, P5, P9) remained unsure, stating that they did not know any costs to the employer from injuries and fatalities.

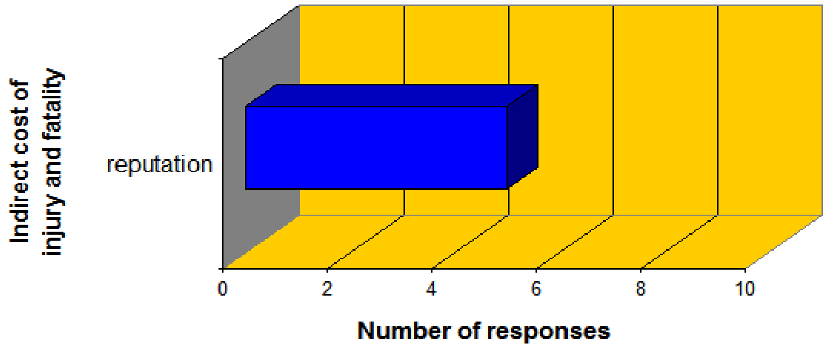


Figure 8: Response aggregation of Interview question No4- Indirect costs of injury and fatality

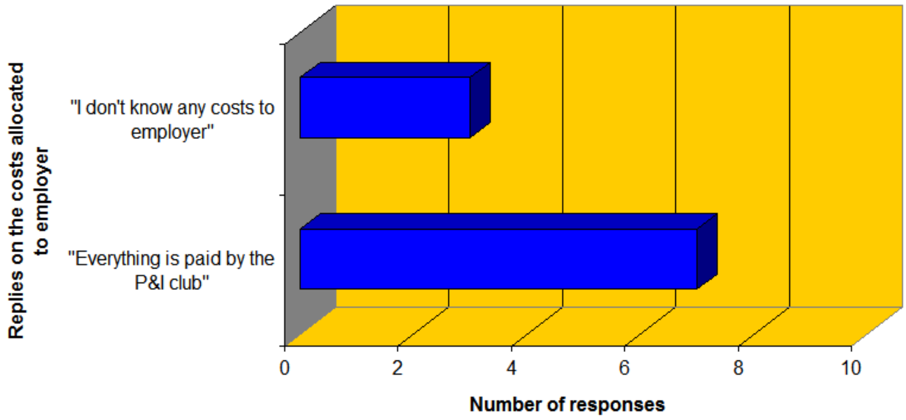


Figure 9: Response aggregation of Interview question No4- Employer's costs

With respect to direct costs (Figure 10), the majority respondents, seven out of ten, (P1, P2, P4, P6, P7, P8, P10) affirmed that loss of productivity occurs whenever an injury or fatality occurs. As P4, P6 and P8 strenuously expressed, ratings will indirectly be discouraged from being active workers, due to the fear of being involved in another accident. Furthermore, the six DPAs (P1, P2, P3, P4, P6, P10) stated that one more impact was the exposure to heavy medical and administrative expenses. Interviewees stated that the company should be ready to deal with these issues on the spot and limit further disruption to the company's financial performance. In this respect, four DPAs (P1, P2, P3, P6) acknowledged that employer's expenses, public or private insurance, and legal costs are included in the administrative costs.

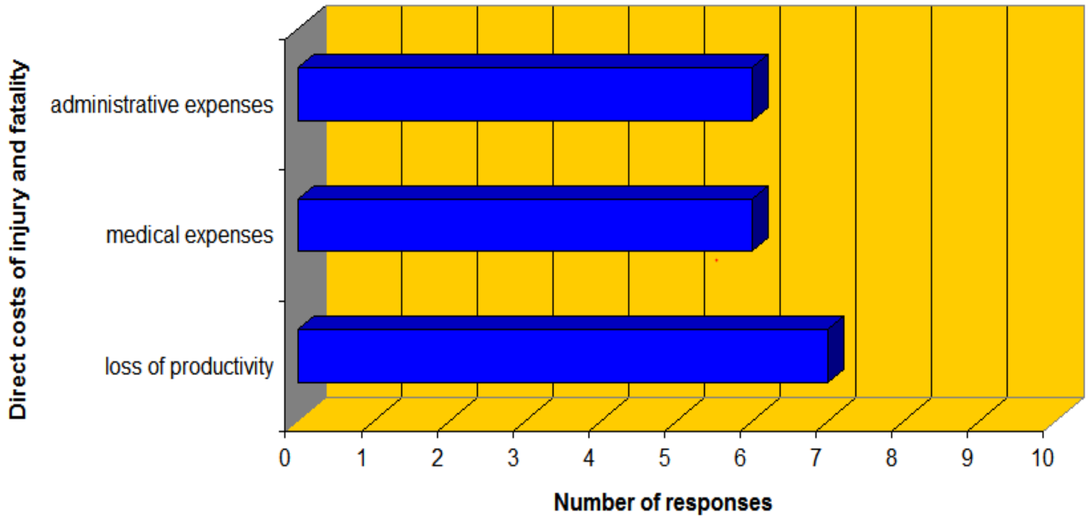


Figure 10: Response aggregation of Interview question No4- Direct costs from injury and fatality

CHAPTER No7: DISCUSSION OF INTERVIEWS

7.1 Discussion of interview question No1 "From a financial point of view, which are the emerging expenses for the establishment of an accident prevention program?"

This study initially set out with the aim of assessing participants' sufficient or insufficient knowledge of the financial aspect of RCOs. The project's results verified that an initial amount of $200.000-290.000 seems imperative to preserve the minimum injury and zero fatality rates. The results of this study further indicate that only 20% of participants from Panamax companies (with 750.000-1.000.000 tons of carrying capacity in their fleets) inclined toward a minimal investment of $60.000-80.000.

It was further found that an investment of $8.200-12.000/year per Aframax vessel for safety equipment is imperative to mitigate the company's lost time injury trends. A consensus on this question becomes apparent as the responses of the interviewees are in line with DeMarco et al. (1997), Bunn et al. (2001) and Angello (2010), confirming that all DPAs and researchers overwhelmingly agree. Prior studies (Jalon et al., 2011 a,b) came in agreement with a markedly low 20% of interviewees, indicating that a company's hidden mission with Panamax vessels is to shrink safety expenditures, by preserving a limited safety budget of just $3000-3100/vessel for safety equipment in an aim to increase company's future investments.

Additionally, the current study found that 60% of participants allocate $280-350/year for accident prevention educational programs for each one of the 615-900 seafarers at senior management levels.

It has also been revealed that the company of P3 (with 225 seafarers at the senior management levels and a fleet of 15 Aframax vessels) maintains a pool of seafarers that is 3.66 times less than the company of P10 (with 825 seafarers and 55 Aframax vessels). Yet, both of these companies invest $200/year per seafarer for fire and safety education programs. This rather contradictory result reveals that:

1. irrespective of company size, there is an equal safety perception between the companies of P3 and P10 and a positive mind-set towards risk prevention measures
2. P3's company's mission includes accident prevention as well as the efforts towards mitigating financial losses from injuries and fatalities on board its vessels.

The remaining findings are rather disappointing, because 20% of interviewees disclosed that their companies do not train any of their 225-300 seafarers on an annual basis on senior management levels. It is evident that the ill-conceived notion that "seafarers will flee educated to other companies" provides further support for the hypothesis that a weak link among certain companies hampers any investment in fire and safety educational programs. On this basis, the principal impediment seems to be the cost of educational programs that is wasted, because, based on managers' perceptions, a non-stable pool of seafarers will choose to leave 'educated' after a few employment contracts to another company. Such a notion has evidently led senior managers to believe that "it is government's duty to train the seafarers" and not the company's duty to do so.

7.2 Discussion of interview question No2 "Based on your professional experience, which are the benefits of investing in RCOs in your company?"

The key objective of this question focused on the correlation between the authors' and managers' viewpoints around the potential benefits of an RCO investment. In fact, the project's results reveal a similarity between DeMarco et al. (1997), Champ and Ornitz (2002), Oxenburg and Marlow (2005) Bottani et al. (2009) and all interviewees verifying the reduction of insurance premiums as the top benefit from an RCO investment. The results of this study not only confirm that Aframax and Panamax shipping companies want to utilize RCOs as a marketing lure that attracts charterers but also uncovers that companies indirectly aspire to increase their future investments by reducing their P&I premiums.

This study sought also to determine the benefits that need to be taken into consideration when a tanker shipping company invests in RCOs. A significantly low number of respondents (30%) affirmed that RCOs safeguard seafarers from exposure to slips and falls. Yet it cannot be assumed that 70% of participants lack safety culture because 90% of them disclosed the mitigation of injury and fatality incidents as the second emerging benefit of RCOs.

Curiously, only 30% seem to believe that investment in RCOs retains employee's commitment. What is even more surprising is that 70% of participants' companies indirectly invest in RCOs in an effort to attract and retain charterers on tanker vessels. Likewise, it becomes apparent that 60% of participants' companies act under this technique so as to decrease the off-hire time of their fleet.

Interestingly, 50% of interviewees (employed in Aframax companies with 675-840 seafarers) accord with DeMarco et al.'s (1997) earlier observations, which proved that investment in RCOs will reduce the seafarers' hospital hours and the lost time injury rate.

Furthermore, only the safety managers (representing 20% of interviewees, with 2-4 years of shore side experience employed to handle Panamax vessels) were able to disclose that the company's fleet will increase by investing in RCOs. From this rather contradictory result, one may assume that:

1. irrespective of their 7-18 years of shore side experience, none of the DPAs (representing 80% of participants on Aframax companies) were able to disclose this benefit, verifying their potentially limited knowledge on the subject matter, or
2. that DPAs just follow a different strategy compared to safety managers by retaining their large tanker Aframax tanker fleet at a stable number since current charter rates are low.

This also reveals that the key aim of the two smallest companies of this project (with 750.000-1.000.000 tons of crude oil carrying capacity) compared to larger companies (with 1.500.000-6.000.000 tons of carrying capacity) is:

1. to reduce expenditure on seafarers' trainings,
2. focus their investment on RCOs,
3. so as to indirectly expand the company's fleet.

7.3 Discussion of interview question No3 "According to your professional experience, are there any barriers that restrict the investments on RCOs?"

The third question was posed with an ulterior motive of revealing the reasons that hamper investment in RCOs, while a second objective was to observe the level of interviewees' knowledge on the subject matter. The project's findings were rather disappointing as far as the initial objective of this study is concerned since more reasons were revealed than were initially considered.

To begin with, it becomes evident that the key obstacle originates from Aframax and Panamax companies that lack proactive vision towards investment in RCOs, coming in direct agreement with Kamil and Deha (2001). The project presents clear evidence that nobody wants to hear because it does not fit their misconceptions. It is highly likely that if investment in RCOs is considered by 80% of interviewees as a way of being exposed to severe financial expenditures, then the return on investment will equally be considered insignificant, making safety an issue of secondary value in any shipping company. Surprisingly, 60% of interviewees reflect Aviva (2011) and Stopford's (2013) conclusions that a drop in freight rates hinders safety investments during recession periods. Thus, this study suggests that crude oil shipping companies aim at capitalizing on safety, concurring with what Jalon et al. (2011 a,b) previously advocated. Finally, they aim to stockpile wealth by reducing ship safety equipment, based on 80% of interviewees and their 6-8 years of on board experience as captains.

This study not only confirms that 30% of participants concur with Pierobon's (2012) observations, which exposed the absence of cost/benefit analyses and lack of financial analysis at a corporate level, but also match with Dorman's (2000) observations, verifying that the notion '*everything is covered by the P&I club'* hampers investment in ROCs. It is also interesting to note that of all cases, this study chooses those of Brody et al. (1990) and Jalon et al. (2011 a,b) because these substantiate that the aforementioned hindrances indeed restrict the mitigation of marine related injuries and fatalities.

7.4 Discussion of interview question No4 "When there is an injury or fatality incident in your company, what do you think is the cost that the employer is exposed to?"

Interview question 4 aspires to determine the costs that the employer is exposed to in case of injury or fatality, and, secondarily, reveal the interviewees' knowledge on the subject matter.

As a starting point, it is encouraging to compare the responses of 50% of interviewees with what was previously found by researchers. This percentage (serving as DPAs and managing 45-60 Aframax vessels) exposed that damage to the company's reputation is the utmost indirect cost that the employer is exposed to in the occurrence of injuries and fatalities. On this basis, it can be implied that:

1. the remaining 50% of interviewees (being safety managers and DPAs employed in companies with 15-20 Panamax and 15-42 Aframax) do not mirror the conclusions of by Liaoming (2005), Neumann and Weintrit (2013), and Maniati (2014) which exposed "reputation" as one of the key indirect costs, and
2. that 50% of interviewees are still unaware of the indirect costs of injuries and fatalities.

Sadly, there is an ongoing bias among 70% of interviewees (with 2-10 years of shore side experience) who believe that injury and fatality expenses are entirely covered by the P&I club. In fact, by examining the reality, this project verifies that Dorman's (2000) and Morrison's (2017) observations have merit, disclosing that companies will continue to be exposed to indirect and unknown costs from this ill-conceived perception.

Additionally, by way of deduction, it can be implied that only 30% of interviewees (P1, P6 and P10 serving as DPAs on the 3 biggest Aframax companies as of 5.500.000-6.000.000 crude oil carrying capacity, and with shore side experience of 15-18 years) are aware that this conclusion is invalid. In fact, this comparison reveals that the same interviewees in question 3 of this project disclosed that this ill-conceived perception hampers investment in RCOs and, as a result, the mitigation of injuries and fatalities on board.

The project's results provide further support for the hypothesis that 30% of participants (managing tanker fleets of 750.000-1.500.000 tons of carrying capacity with 2-7 years shore based experience) are totally unaware of the employer's costs in case of injuries and fatalities. The present findings seem to verify the continuation of indirect and unknown costs along with the insufficient financial knowledge from shore side personnel as previously found by Kamil and Deha (2001).

This study, apart from exposing that 70% of interviewees (with 615-900 seafarers on senior management ranks) are cognizant of the productivity losses in case of an injury and fatality, further reveals that 30% of interviewees (with 225-300 seafarers on senior management positions) are unaware that productivity directly impacts the company's financial activities.

It is also suggested that 40% of the participants are:

1. still financially exposed to heavy medical and administrative expenses (e.g public or private insurances & legal costs), and
2. that maintain an insufficient level of knowledge on the direct costs of injuries and fatalities which indirectly hampers any implementation of RCOs.

On the contrary, it is evident that 60% of participants are in line with DeMarco et al., (1997), Champ and Ornitz (2002), and Maniati (2014), verifying their sufficient level of knowledge of the direct costs of injuries and fatalities.

In reviewing the results section, the quest for a common assumption between interviewees and researchers proved futile since none of the interviewees disclosed any monetary value of injuries and fatalities. Whatever the reason might be, everyone will agree that direct and indirect costs are indeed confidential, and, as such, very difficult to disclose to an investigator that is not engaged in the participant's company. Thus, this project suggests that there is abundant room for further research in determining the monetary value of injury and fatality incidents.

7.5 Summary of discussion section

It has been previously discussed that there is a tendency among shipping companies to minimize 'unnecessary safety expenditures'. There is also an assumption that there is limited knowledge on the part of managers of the economic benefits and losses when RCOs is the area under discussion. If companies continue to think and act in this manner, it can be assumed that they will be exposed to injuries, fatalities, direct, indirect, unknown and employer's costs as well as a huge expense of $82.000 per disabling injury and $3.400.000 per fatality incident. Yet, companies can invest and benefit from at least the four proposed RCOs in this project and limit the probability of fire, explosion, grounding and collision events or the exposure to the aforementioned expenditures.

Additionally, one might assume that the sample or the answers of the specific participants are not relevant or representative of the industry, or that the interviewer might have simply talked to the wrong individuals, which may influence the project itself. Before making any global recommendations, and in an effort to validate the relatively small sample of ten participants, a comparison and discussion of the results of other studies was performed. On this basis, it can now be stated that the extracted findings and discussion section are in line with the standpoint of previous researchers and their comprehensive studies.

In fact, the current study differs from others because it combines an initial proposal from MEPC 58/INF.2 as well as its critical review MSC 91/WP.6 (2012) in one project to extract its conclusions. Furthermore, this study furnished a percentage analysis of the direct and indirect costs of injuries and fatalities (Table 8) so as to give another point of view on the subject matter.

CHAPTER 8: CONCLUSIONS & RECOMMENDATIONS

The first chapter of this project sought to determine the problems that lead to constant injuries and fatalities in shipping companies as well as the absence of proper investment in RCOs. This dissertation succeeded in determining that this is mainly due to the lack of investment in RCOs, which is indirectly triggered by a lack of knowledge (from the corporate side) on the economic benefits of RCOs.

Despite the limits of the methodology section in chapter 2, this project succeeded in obtaining the necessary data from 10 Greek shipping companies from 8 Greek DPAs and 2 safety managers as well as from world casualty statistics, MSC 91/WP.6 (2012), MEPC 58/INF.2 (2008), MSC-MEPC.2/Circ.12 (2013), and DeMarco et al.'s (1997) observations.

This dissertation succeeded to reveal that:

1. direct costs are more dominant compared to the indirect costs, and
2. the average cost of accidents to companies is hard to be identified, especially when insurance is covering the largest portion of it.

With respect to project's limitations, this project focuses entirely on Panamax and Aframax crude oil tankers in Greece. At a second stage, it did not evaluate the costs to society or disabled individuals but emphasized the tanker shipping company itself. Finally, irrespective of the significantly lower number of fatalities in the tanker shipping industry, tanker accidents prove to be the most expensive ones compared to other maritime sectors.

This project was able to substantiate in Table 7 that passenger vessels lead to the most costly disabling injuries compared to tugs, and tanker vessels with a cost of $104.000, followed by tanker vessels (with a difference of $21.500 less compared to passenger vessels), which equals $82.500 per disabling injury.

Even if the tanker shipping industry experiences the fewest number of accidents, it has been proved that a single fatality in tanker shipping shall be expected to generate a total loss of $3.400.000 (Table 7), which is far above the costs within passenger and tug sector. This study documents that employer's costs alone represents 9,52%, while indirect costs represent 67,12%, as extracted from the distribution of percentage analysis of injuries and fatalities. Furthermore, total indirect costs proved to be 19 times more than employer's costs alone (Table 6, 8).

This project further explored four RCO models in an effort to mitigate maritime hazards leading to fatalities in Aframax and Panamax crude oil tankers. This project succeeded in revealing the economic benefit and implementation costs of these RCOs and categorizing them based on their individual cost effectiveness. From the analysis of RCOs it can be concluded that the crisis of fire and explosion incidents must be addressed. Thus, to alleviate the current situation, RCO 3: “hot work procedures training” is proposed for direct implementation since this RCO maintains significantly lower GCAF compared to RCO 1: “active steering gear redundancy”, and RCO 2: “navigational sonar”. Despite its exploratory nature, this study argued that RCO 2 is very costly to implement on every tanker, especially when shipping companies maintain a fleet of 50-60 crude oil tankers. In spite of RCO 2’s economically beneficial status, it is not proposed for prompt implementation due to its high implementation cost. However, it is considered to be a vitally important intervention to install RCO 2 on new building projects. With reference to RCO 4: engine control room additional emergency exit, the project’s results showed that NCAF maintains an identical rate to the GCAF because this RCO is used for escape purposes only, so profit-wise it is not adequate for implementation. Irrespective of the aforementioned, it would be a grave error to neglect this RCO. In fact, companies are prompted to implement it in an effort to mitigate onboard fatalities.

From the interviews completed, evidence emerged that insurance coverage has partially blinded senior managers both to the expense and the extent of injuries and fatalities. Since insurance markets are markedly impaired by the magnitude and the number of maritime losses, companies in the tanker shipping spectrum are expected to experience premium increases or even limited coverage.

The current piece of work contributes to existing knowledge regarding accident costs by verifying that multiple constraints may hamper:

1. the mitigation of injuries and fatalities on board, and
2. the investments in RCOs.

The heavy burden of responsibility proved to lay in the hands of shipping companies which aspire to preserve a limited safety budget in an aim to upsurge company's future investments. The situation has been exacerbated by certain companies which further restrict the implementation of educational programs by arguing that it is the government's job to train seafarers or that the seafarers will flee educated to other companies. Such evidence allows this project to further conclude that the key obstacle originates from Aframax and Panamax companies that lack a proactive vision toward investment in RCOs.

Although the current study was conducted utilizing a small sample of participants, its findings suggest that senior shore based personnel consider RCOs as an extravagant expense, especially during recession periods. Key factors which have proved to hamper investment in ROCs and restrict the mitigation of maritime related injuries and fatalities are the absence of cost/benefit analyses and the lack of long-term financial analysis at a corporate level. This study further succeed to expose the limited knowledge of senior manages due to their ill-conceived perception ‘injury and fatality expenses are entirely covered by the P&I club’.

In fact, the present study was also designed to determine the reasons that shipping companies indirectly invest in RCOs. On this basis, this study exposed that any promising reduction of insurance premiums, increase in future investments and promotion of economic interests indirectly trigger shipping companies to invest in RCOs. The indirect aim of shipping companies to stockpile wealth from the reduction of safety investments is clearly supported by the project’s findings. This study further suggests that crude oil shipping companies aspire to decrease the off-hire time of their fleet by utilizing RCOs as a marketing lure that attracts potential charterers.

The prospects for the future will be bleak unless the insufficient budgetary knowledge from shore side personnel is enhanced. If not, tanker shipping companies will financially bleed as a result of heavy medical and administrative losses. On the contrary, this research extends current knowledge of damage to the company’s reputation as the utmost indirect cost to employers in the occurrence of injuries and fatalities.

In order to generalize the outcome of this study there is a need to invest in a full scale research with:

1. all maritime sectors and international perspective,
2. all companies, and
3. all accidents.

That is because investment on safety proved to provide long-term benefits. In fact, investment in RCOs should not be considered as a waste of money in the short term but as a long term profit. It is further demonstrated that investment in safety makes sense, but today adequate investment is not properly applied. In order to do so, comprehensive research should be performed, while each single company should investigate this issue separately.

The development of costs regarding oil spills and property damage, separated into different maritime sectors with an emphasis on the tanker shipping industry, definitely merits further investigation. On balance, it is believed that studies which assess the impact of injuries and fatalities to society and the injured individuals remain as a challenge which must also be met in the future.

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APPENDIX SECTION

Appendix 1: Interview Guide

Topic of investigation:
" A COST-BENEFIT ANALYSIS OF THE RISK CONTROL OPTIONS TOWARDS MITIGATING MARITIME HAZARDS LEADING TO INJURIES AND FATALITIES IN TANKER SHIPPING COMPANIES: A case study "

Interview Introduction - 2017

Dear Participant, my name is Polyzois Antonios and I am a currently an Msc student at the World Maritime University, in Sweden. For my Msc thesis, I intent to examine any costs that relate to a safety investment as well as its interrelated benefits. Any provided data will support the future safety managers with thought provoking information regarding risk control options in an effort to avert injuries and fatalities on board tanker vessels.

Since you are currently an active individual in your shipping company, I take this initiative of inviting you to participate in this research study by enabling me to perform an in-depth interview on the afore mentioned subject matter.

The duration of this interview will need maximum one hour of your valuable time. Any personal interview is strictly voluntary and highly appreciated. In case you may want to cease the interview or refuse to answer you are willing to do so.

The interview initiates with the explanation/description of the current project. It is after followed by the signing of the "Research informed consent form", the demographic table given each participant and finally the main "Interview questions".

Even if there is absence of compensation from this interview, any extracted findings will be allocated on the advantage of maritime safety so to enhance the richness of creditable knowledge by revealing thought provoking perspectives.

Confidentiality will be preserved during and after the interview with non-public information to be concealed, limiting the disclosure of information only around combined results from the chosen interviews. Any generated findings are to publicly available after the fulfilment of my studies. Bear in mind that this interview was approved by the Research Ethics Committee of the World Maritime University.

Having said that, in case you oppose to the manner of this interview, you may anonymously and directly complain to my supervisor or co-supervisor:

- Professor Jens-Uwe Schröder, jus@wmu.se
- Armando Graziano, agr@wmu.se

In case of further information or additional questions please do not hesitate to contact me at:

- Polyzois Antonios + 30 6982294454, s17502@wmu.se

Participant's information

1) Name* ____

2) Organisation ____

3) Email* ____

Definitions

Safety Costs:

These costs may cover either costs of investments to prevent an unwanted event or costs/expenses that have been occurred due to the absence of safety investment. These two concepts are totally different, so it is preferable to distinguish any interrelated differences.

Safety benefits:

These might cover, but not limited, to the generation of positive results in the short or long run. Any answers shall be limited to the tanker shipping industry, either by covering monetary values or simple statements such as i.e enhancement of knowledge.

Research informed consent form

WMU LETTERHEAD

Title of research:

" A COST-BENEFIT ANALYSIS OF THE RISK CONTROL OPTIONS TOWARDS MITIGATING MARITIME HAZARDS LEADING TO INJURIES AND FATALITIES IN TANKER SHIPPING COMPANIES: A case study"

Candidate:

I..(Name)

of...(Organization)

have made an agreement to voluntarily take part in this research project.

I indeed verify that I am cognizant of the main purpose as well as the key objectives of the current research and guaranteed of the confidentiality of this interview.

As far as this interview is concerned, I consent / do not consent of being voice-recorded.

Pursuant to the above, I agree to share such information to writings related to this case study or subsequent publications that are necessitated for the purpose of the current project.

Signed:

....

Name   Date

Demographics table

1) How old are you? (Age in years)

2) Have you served on board as captain?

3) If you have served onboard, how many years of experience do you have at sea?

4) Please indicate your current position

5) Experience in the field at the shore? For how long have you held this position?

6) How many vessels does your company have?

7) How many seafarers from the top management are recruited at your company?

8) How many seafarers from the top management levels does your company train?

9) What is approximately the total carrying capacity of your crude oil tankers in tons?

10) What kind of crude oil carriers does your company have?

Appendix 2: Interview questions

In this respect, interview question No1:

" From a financial point of view, which are the emerging expenses for the establishment of an accident prevention program?"

- Would you like to add more based on your professional experience on board regarding the emerging expenses?

Interview question No2:

" Based on your professional experience, which are the benefits of investing in RCOs in your company?"

- Would you be able to expand on the financial benefits specifically?

Interview question No3:

"According to your professional experience, are there any barriers that restrict the investments on RCOs?"

Interview question No4:

" When there is an injury or fatality incident in your company, what do you think is the cost that the employer is exposed to?"

- Could you elaborate more on the costs in case of injury or fatality on board?
- Could you split costs in direct and indirect costs?

Thank You!
I want to express my sincere gratitude for choosing to participate in my interview! Your assistance will furnish fruitful information to the whole maritime safety spectrum by promoting innovation into the current tanker shipping industry.
Best regards,
Polyzois Antonios

Appendix 3: International regulations

COLREG: Convention of the international regulations for preventing collisions at sea.
SOLAS: International Convention for the safety of life at sea (Routeing systems, Fire safety provisions)
MOU: Memorandum of Understanding
STCW: International Convention on Standards of Training, Certification and Watchkeeping
ARPA: Automatic Radar Plotting Aid
VETTING measure
MARPOL: Enhanced Special inspection Program
OPA90: Oil Pollution Act
GMDSS: Global Maritime Distress and Safety System
ETS: European Telecommunications Standard
ISM: International Safety Management Code
CAP: Condition Assessment Program
ILO: International Labour Organisation

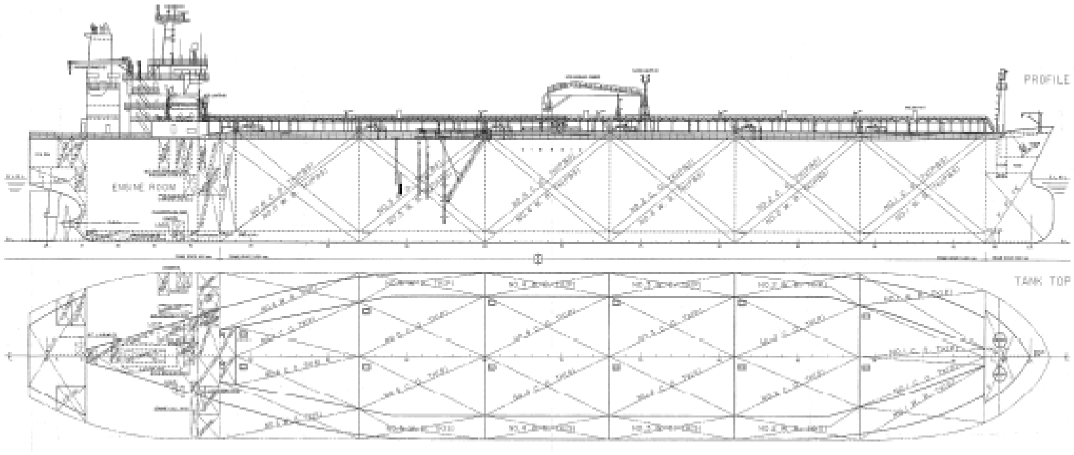
Source: MEPC, 2008

Appendix 4: Basic characteristic of the Panamax tanker

Ship size	PANAMAX
Length, oa	228.00m
Length, bp	219.00m
Breadth, moulded	32.20m
Depth, moulded (main deck)	19.80m
Width of double skin sides	2.075m
Double bottom height	2.040m
Draught, moulded, scantling	13.60m
Deadweight, scantling draught (comparable with design proposed)	69,684dwt
Capacities (100%) Liquid volume, heavy oil, diesel oil, Water ballast	 80,659m^3 (of which 1,445m^3 are Slops), 1,419m^3, 195m^3 29,687m^3 (of which 2,377m^3 are peak tanks)
Classification	Lloyd's Register
Propeller Diameter	6,700 mm
Number of Cargo tanks	12 plus 2 slop tanks
Typical cargo tank volumes	No.1 P/S each 4,926m^3, No.2 P/S each 7,009m^3 No.3 P/S each 7,078m^3, No.4 P/S each 7,078m^3 No.5 P/S each 7,059m^3, No.6 P/S each 6,458m^3 Slop Tanks P/S each 722.6m^3
Cargo Tanks block length	170.52 m

Source: MEPC, (2008)

Appendix 5: Panamax tanker, General arrangement, side and top view



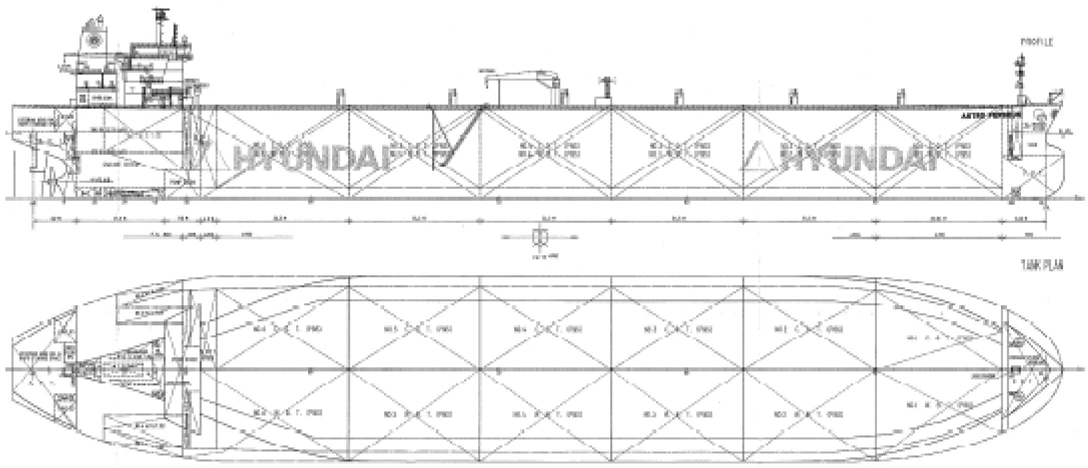
Source: MEPC, (2008)

Appendix 6: Basic characteristic of the Aframax tanker

Ship size	AFRAMAX
Length, oa	248.00m
Length, bp	238.00m
Breadth, moulded	43.00m
Depth, moulded (main deck)	21.00m
Width of double skin sides	2.18m
Double bottom height	2.30m
Draught, moulded, scantling	14.30m
Deadweight, scantling draught (comparable with design proposed)	105,357dwt
Capacities (100%) Liquid volume, heavy oil, diesel oil, Water ballast	 125,203m^3 (of which 2,424m^3 are Slops), 3,339m^3, 231m^3 39,783m^3 (of which 3,218m^3 are peak tanks)
Classification	Lloyd's Register
Propeller Diameter	8,000 mm
Number of Cargo tanks	12 plus 2 slop tanks
Typical cargo tank volumes	No.1 P/S each 8,003m^3, No.2 P/S each 10,796m^3 No.3 P/S each 10,872m^3, No.4 P/S each 10,872m^3 No.5 P/S each 10,872m^3, No.6 P/S each 9,976m^3 Slop Tanks P/S each 1212m^3
Cargo Tanks block length	184.90 m

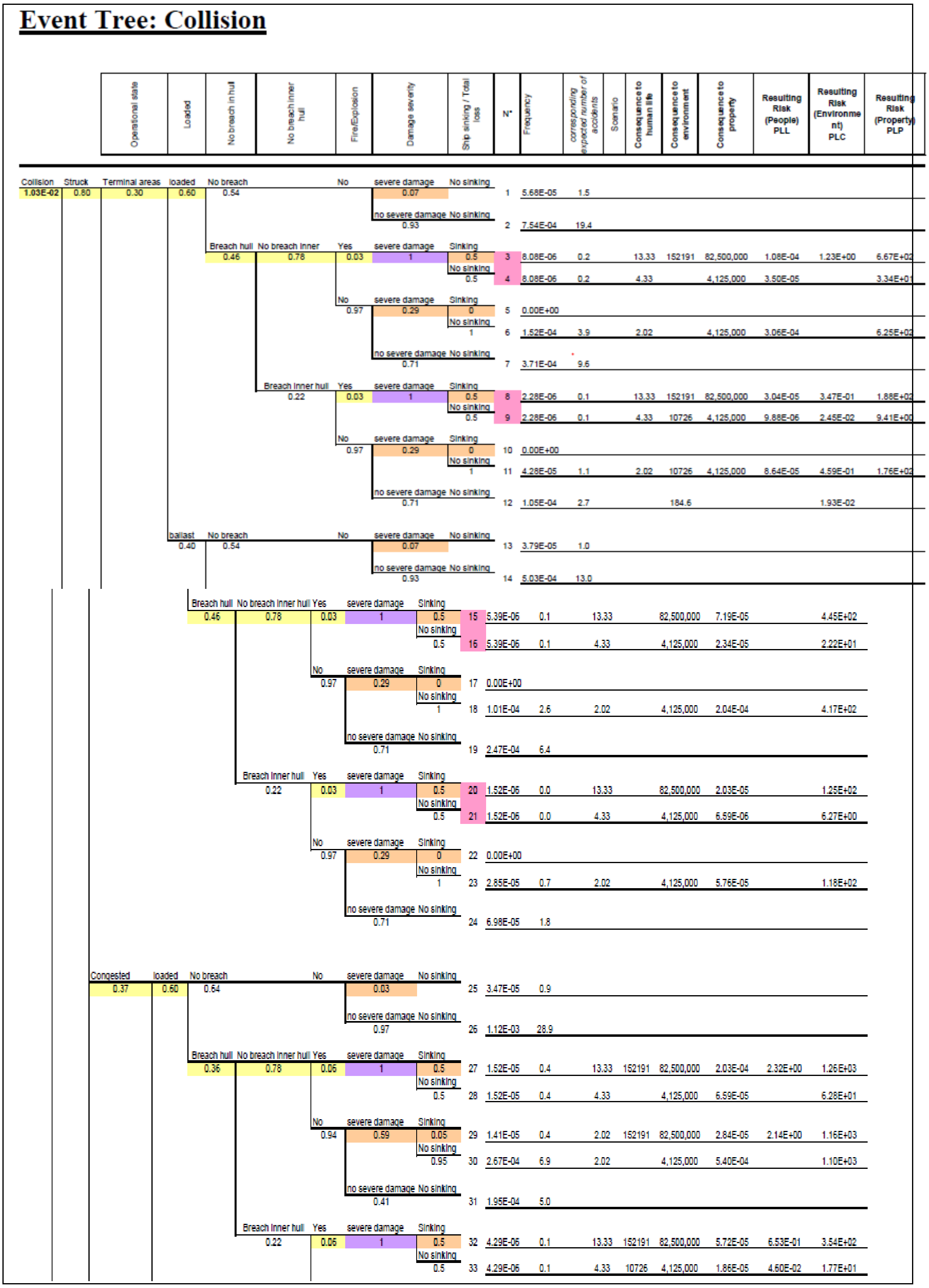
Source: MEPC, (2008)

Appendix 7: Aframax tanker, General arrangement, side and top view



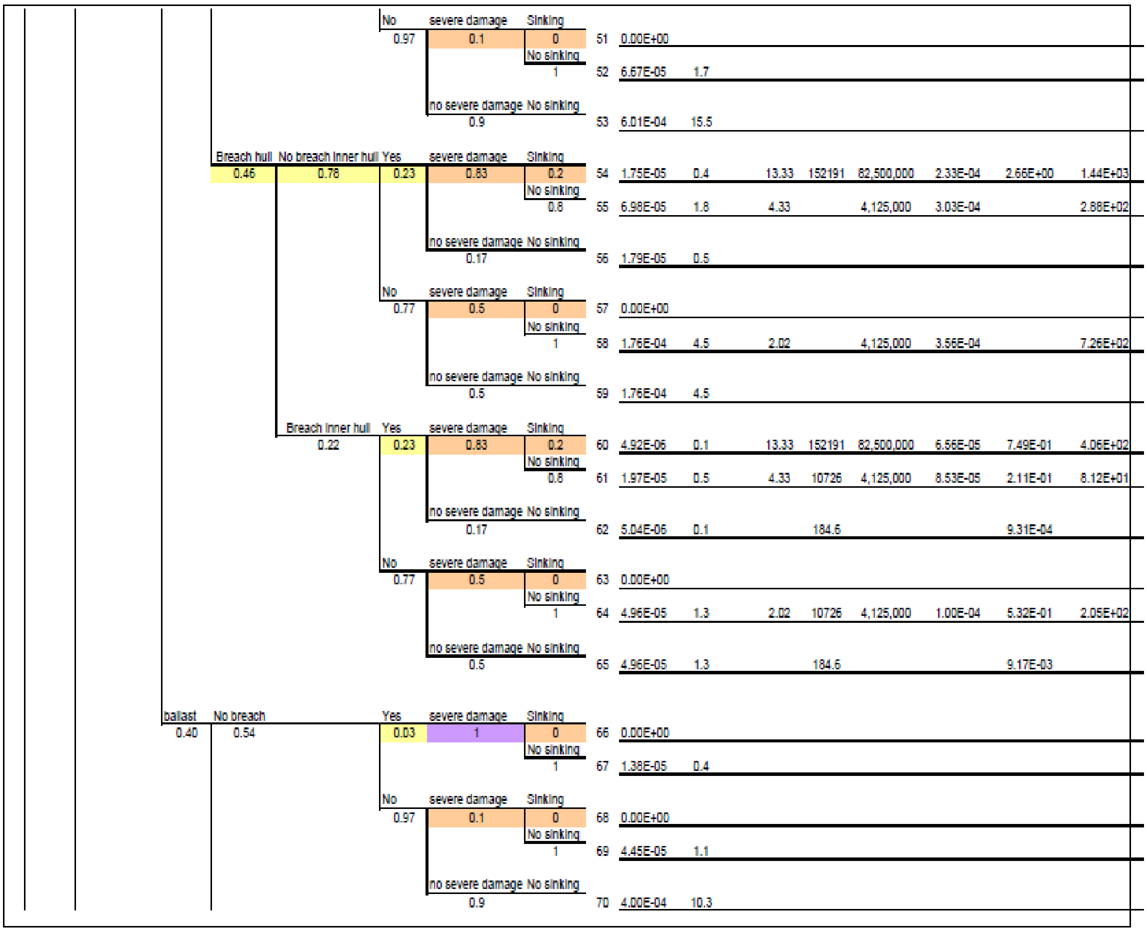
Source: MEPC, (2008)

Appendix 8: Event tree - Collision

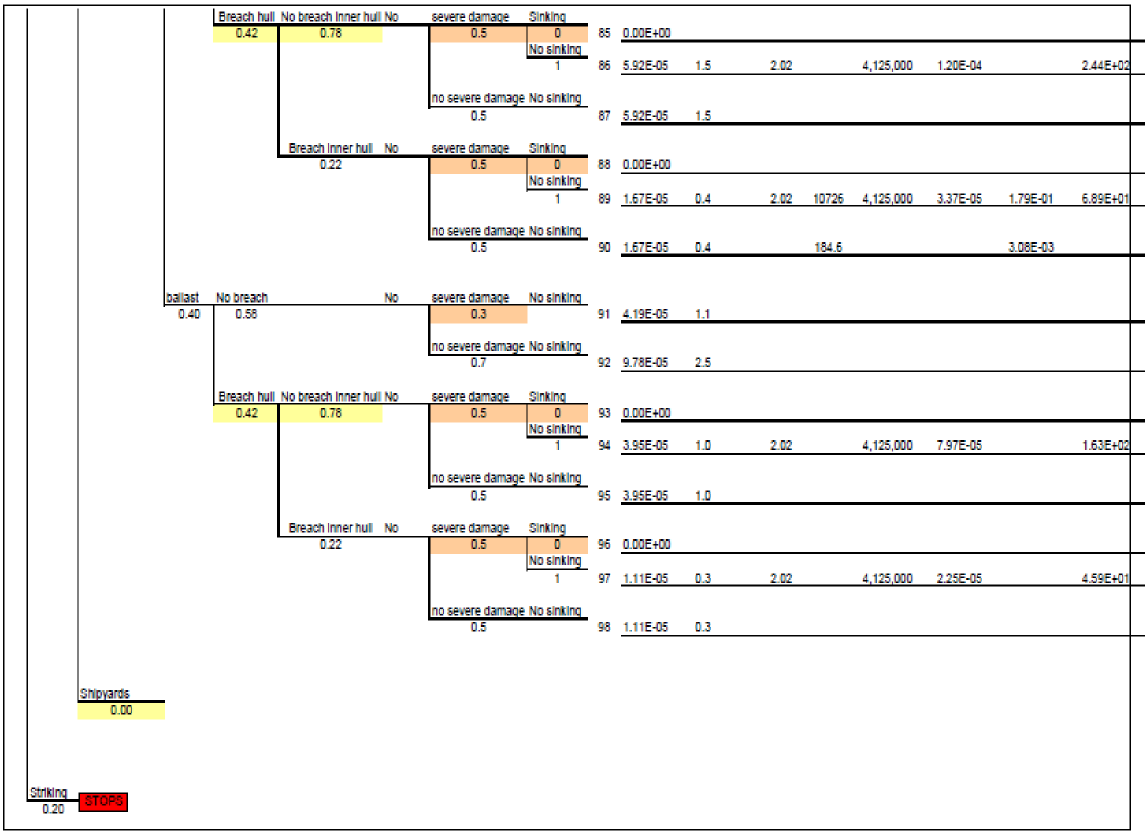


No 0.94	severe damage 0.59	Sinking 0.05	34	3.97E-06	0.1	2.02	152191	82,500,000	8.01E-06	6.04E-01	3.27E+02
		No sinking 0.95	35	7.54E-05	1.9	2.02	10726	4,125,000	1.52E-04	8.09E-01	3.11E+02
	no severe damage 0.41	No sinking	36	5.51E-05	1.4		184.6			1.02E-02	

Operational state	Loaded	No breach in hull	No breach inner hull	Fire/Explosion	Damage severity	Ship sinking / Total loss	N°	Frequency	corresponding expected number of accidents	Scenario	Consequence to human life	Consequence to environment	Consequence to property	Resulting Risk (People) PLL	Resulting Risk (Environment) PLC	Resulting Risk (Property) PLP
	ballast 0.40	No breach 0.64		No	severe damage 0.03	No sinking	37	2.31E-05	0.6							
					no severe damage 0.97	No sinking	38	7.48E-04	19.3							
		Breach hull 0.36	No breach inner hull 0.78	Yes 0.06	severe damage 1	Sinking 0.5	39	1.01E-05	0.3		13.33		82,500,000	1.35E-04		8.37E+02
						No sinking 0.5	40	1.01E-05	0.3		4.33		4,125,000	4.40E-05		4.18E+01
				No 0.94	severe damage 0.59	Sinking 0.05	41	9.38E-06	0.2		2.02		82,500,000	1.89E-05		7.74E+02
						No sinking 0.95	42	1.78E-04	4.6		2.02		4,125,000	3.60E-04		7.35E+02
					no severe damage 0.41	No sinking	43	1.30E-04	3.4							
			Breach inner hull 0.22	Yes 0.06	severe damage 1	Sinking 0.5	44	2.86E-06	0.1		13.33		82,500,000	3.82E-05		2.36E+02
						No sinking 0.5	45	2.86E-06	0.1		4.33		4,125,000	1.24E-05		1.18E+01
				No 0.94	severe damage 0.59	Sinking 0.05	46	2.64E-06	0.1		2.02		82,500,000	5.34E-06		2.18E+02
						No sinking 0.95	47	5.03E-05	1.3		2.02		4,125,000	1.02E-04		2.07E+02
					no severe damage 0.41	No sinking	48	3.68E-05	0.9							
Open Sea 0.26	loaded 0.60	No breach 0.54		Yes 0.03	severe damage 1	Sinking 0	49	0.00E+00								
						No sinking 1	50	2.06E-05	0.5							

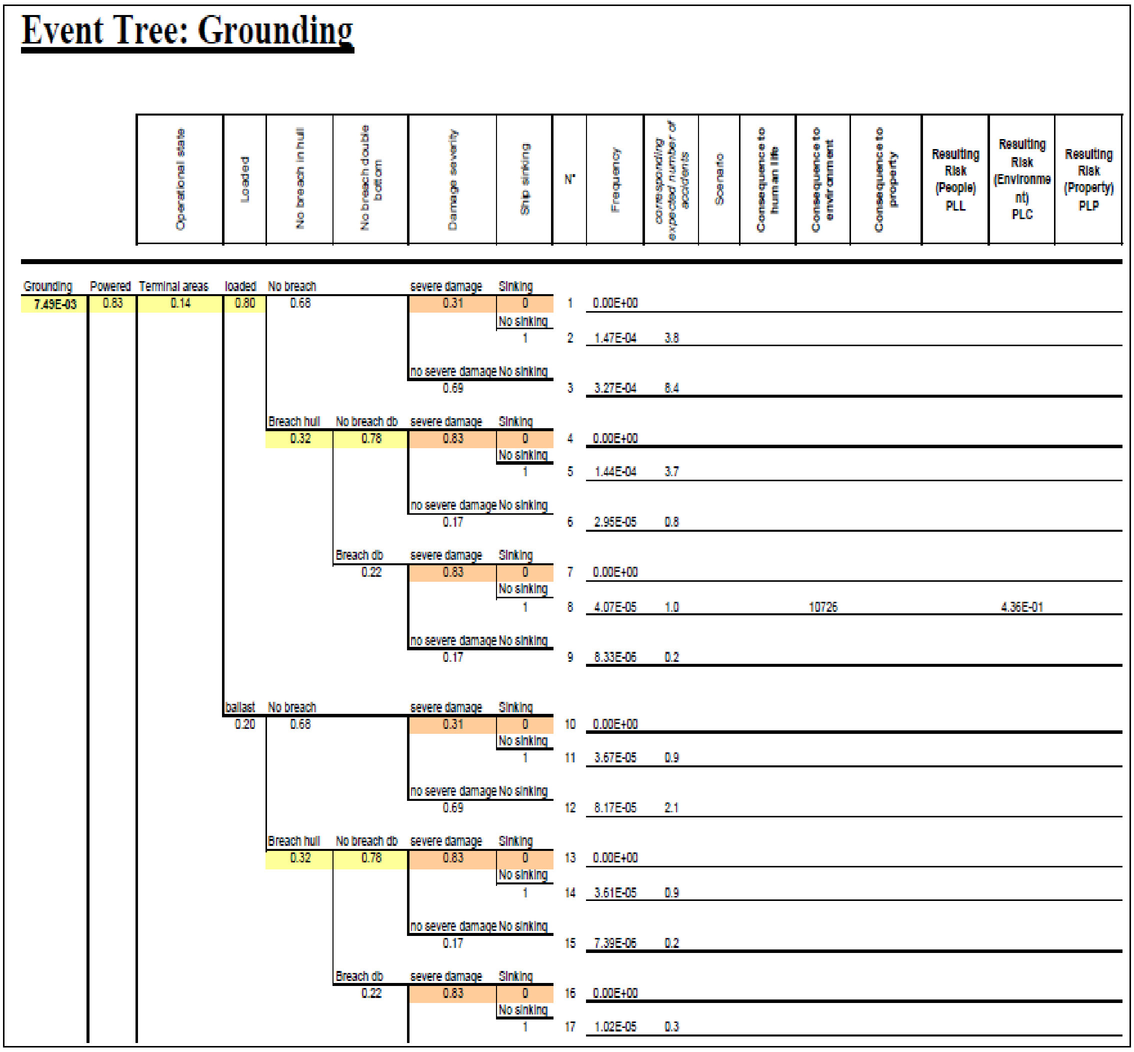

No
severe damage
Sinking
0.97
0.1
0
51 0.00E+00
No sinking
1
52 6.67E-05 1.7
no severe damage No sinking
0.9
53 6.01E-04 15.5
Breach hull
No breach inner hull
Yes
severe damage
Sinking
0.46
0.78
0.23
0.83
0.2
54 1.75E-05 0.4 13.33 152191 82,500,000 2.33E-04 2.66E+00 1.44E+03
No sinking
0.8
55 6.98E-05 1.8 4.33 4,125,000 3.03E-04 2.88E+02
no severe damage No sinking
0.17
56 1.79E-05 0.5
No
severe damage
Sinking
0.77
0.5
0
57 0.00E+00
No sinking
1
58 1.76E-04 4.5 2.02 4,125,000 3.56E-04 7.26E+02
no severe damage No sinking
0.5
59 1.76E-04 4.5
Breach inner hull
Yes
severe damage
Sinking
0.22
0.23
0.83
0.2
60 4.92E-06 0.1 13.33 152191 82,500,000 6.56E-05 7.49E-01 4.06E+02
No sinking
0.8
61 1.97E-05 0.5 4.33 10726 4,125,000 8.53E-05 2.11E-01 8.12E+01
no severe damage No sinking
0.17
62 5.04E-06 0.1 184.6 9.31E-04
No
severe damage
Sinking
0.77
0.5
0
63 0.00E+00
No sinking
1
64 4.96E-05 1.3 2.02 10726 4,125,000 1.00E-04 5.32E-01 2.05E+02
no severe damage No sinking
0.5
65 4.96E-05 1.3 184.6 9.17E-03
ballast
No breach
Yes
severe damage
Sinking
0.40
0.54
0.03
1
0
66 0.00E+00
No sinking
1
67 1.38E-05 0.4
No
severe damage
Sinking
0.97
0.1
0
68 0.00E+00
No sinking
1
69 4.45E-05 1.1
no severe damage No sinking
0.9
70 4.00E-04 10.3

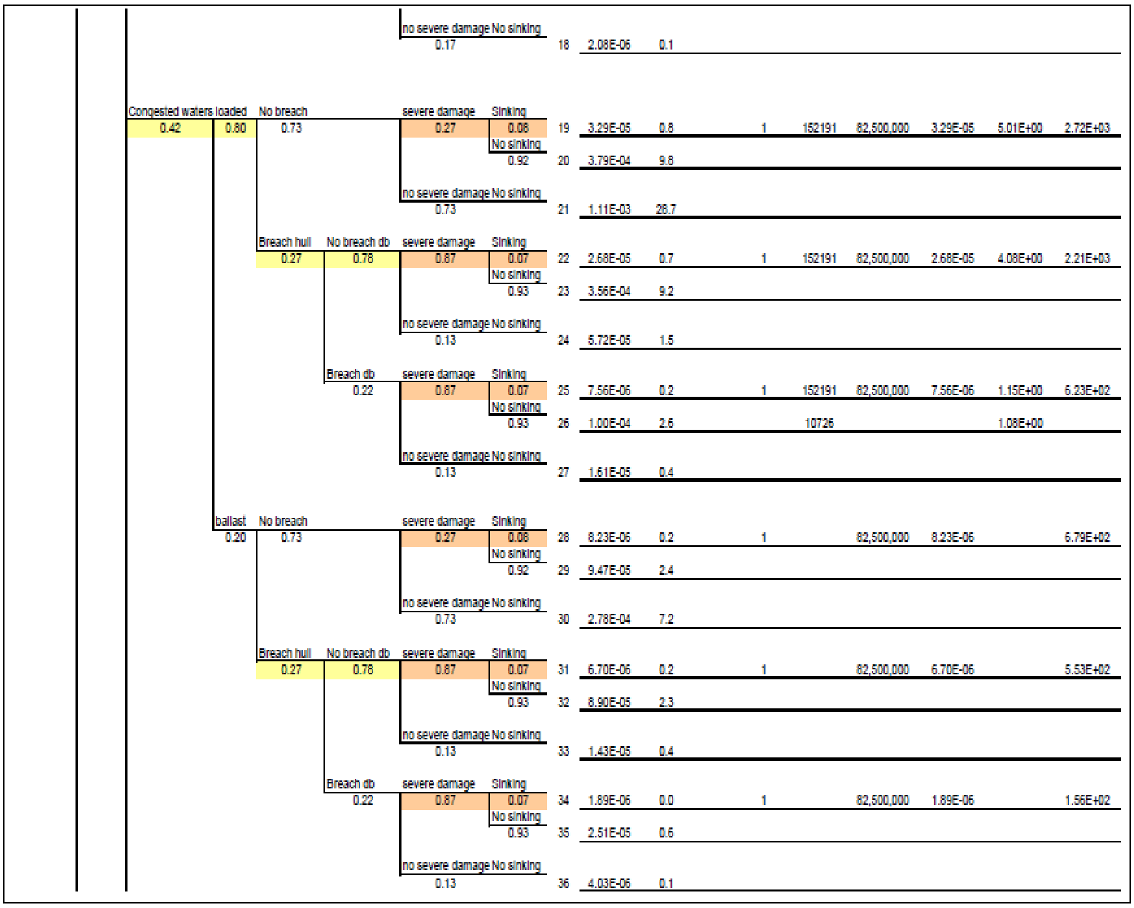
Operational state	Loaded	No breach in hull	No breach inner hull	Fire/Explosion	Damage severity	Ship sinking / Total loss	N°	Frequency	corresponding expected number of accidents	Scenario	Consequence to human life	Consequence to environment	Consequence to property	Resulting Risk (People) PLL	Resulting Risk (Environment) PLC	Resulting Risk (Property) PLP
		Breach hull 0.46	No breach inner hull 0.78	Yes 0.23	severe damage 0.83	Sinking 0.2	71	1.16E-05	0.3		13.33		82,500,000	1.55E-04		9.60E+02
						No sinking 0.8	72	4.65E-05	1.2		4.33		4,125,000	2.02E-04		1.92E+02
					no severe damage 0.17	No sinking	73	1.19E-05	0.3							
				No 0.77	severe damage 0.5	Sinking 0	74	0.00E+00								
						No sinking 1	75	1.17E-04	3.0		2.02		4,125,000	2.37E-04		4.84E+02
					no severe damage 0.5	No sinking	76	1.17E-04	3.0							
			Breach inner hull 0.22	Yes 0.23	severe damage 0.83	Sinking 0.2	77	3.28E-06	0.1		13.33		82,500,000	4.38E-05		2.71E+02
						No sinking 0.8	78	1.31E-05	0.3		4.33		4,125,000	5.69E-05		5.41E+01
					no severe damage 0.17	No sinking	79	3.36E-06	0.1							
				No 0.77	severe damage 0.5	Sinking 0	80	0.00E+00								
						No sinking 1	81	3.31E-05	0.9		2.02		4,125,000	6.68E-05		1.37E+02
					no severe damage 0.5	No sinking	82	3.31E-05	0.9							
Limited waters 0.07	loaded 0.60	No breach 0.58		No	severe damage 0.3	No sinking	83	6.29E-05	1.6							
					no severe damage 0.7	No sinking	84	1.47E-04	3.8							



Source: MEPC, (2008)

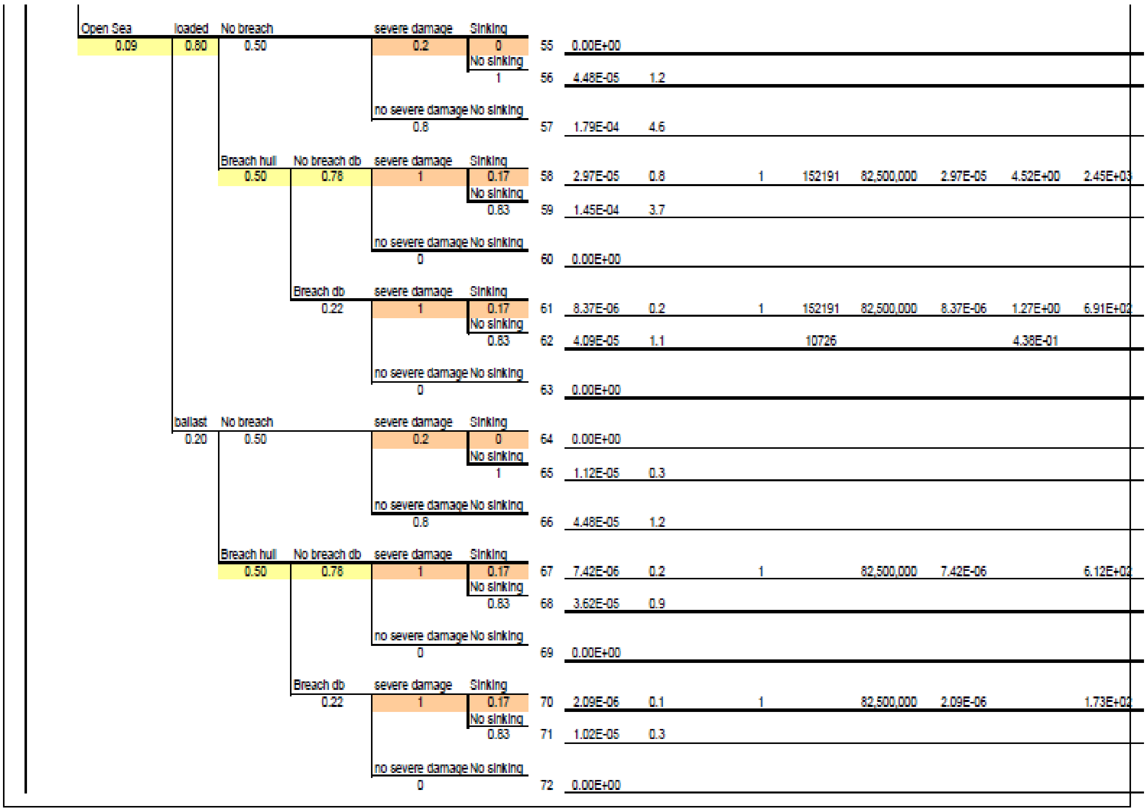
Appendix 9: Event tree - Grounding



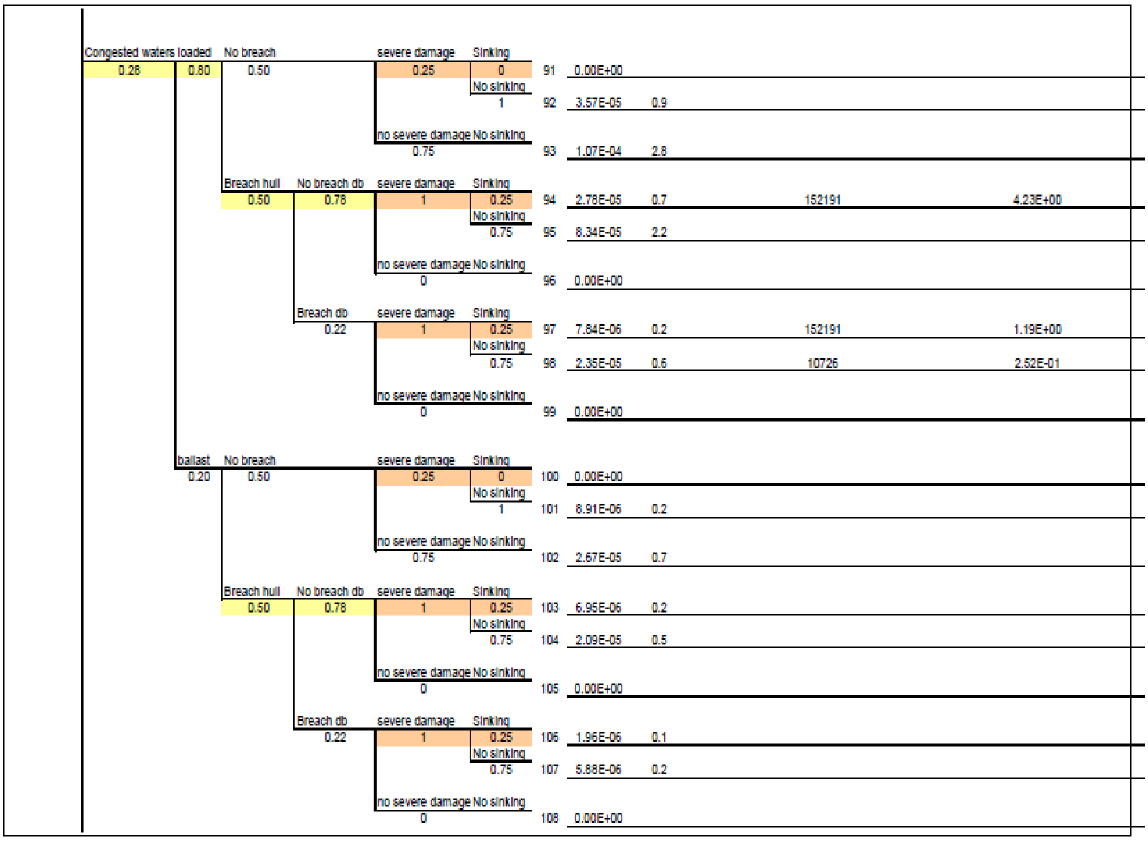


no severe damage No sinking
0.17
18 2.08E-06 0.1
Congested waters loaded
0.42
0.80
No breach
0.73
severe damage
0.27
Sinking
0.08
19 3.29E-05 0.8 1 152191 82,500,000 3.29E-05 5.01E+00 2.72E+03
No sinking
0.92
20 3.79E-04 9.8
no severe damage No sinking
0.73
21 1.11E-03 28.7
Breach hull
0.27
No breach db
0.78
severe damage
0.87
Sinking
0.07
22 2.68E-05 0.7 1 152191 82,500,000 2.68E-05 4.08E+00 2.21E+03
No sinking
0.93
23 3.56E-04 9.2
no severe damage No sinking
0.13
24 5.72E-05 1.5
Breach db
0.22
severe damage
0.87
Sinking
0.07
25 7.56E-06 0.2 1 152191 82,500,000 7.56E-06 1.15E+00 6.23E+02
No sinking
0.93
26 1.00E-04 2.6 10726 1.08E+00
no severe damage No sinking
0.13
27 1.61E-05 0.4
ballast
0.20
No breach
0.73
severe damage
0.27
Sinking
0.08
28 8.23E-06 0.2 1 82,500,000 8.23E-06 6.79E+02
No sinking
0.92
29 9.47E-05 2.4
no severe damage No sinking
0.73
30 2.78E-04 7.2
Breach hull
0.27
No breach db
0.78
severe damage
0.87
Sinking
0.07
31 6.70E-06 0.2 1 82,500,000 6.70E-06 5.53E+02
No sinking
0.93
32 8.90E-05 2.3
no severe damage No sinking
0.13
33 1.43E-05 0.4
Breach db
0.22
severe damage
0.87
Sinking
0.07
34 1.89E-06 0.0 1 82,500,000 1.89E-06 1.56E+02
No sinking
0.93
35 2.51E-05 0.6
no severe damage No sinking
0.13
36 4.03E-06 0.1

Operational state	Loaded	No breach in hull	No breach double bottom	Damage severity	Ship sinking	N°	Frequency	corresponding expected number of accidents	Scenario	Consequence to human life	Consequence to environment	Consequence to property	Resulting Risk (People) PLL	Resulting Risk (Environment) PLC	Resulting Risk (Property) PLP
Limited waters 0.35	loaded 0.80	No breach 0.85		severe damage 0.15	Sinking 0	37	0.00E+00								
					No sinking 1	38	2.22E-04	5.7							
				no severe damage 0.85	No sinking	39	1.26E-03	32.4							
		Breach hull 0.15	No breach db 0.78	severe damage 1	Sinking 0	40	0.00E+00								
					No sinking 1	41	2.04E-04	5.3							
				no severe damage 0	No sinking	42	0.00E+00								
			Breach db 0.22	severe damage 1	Sinking 0	43	0.00E+00								
					No sinking 1	44	5.74E-05	1.5			10726			6.16E-01	
				no severe damage 0	No sinking	45	0.00E+00								
	ballast 0.20	No breach 0.85		severe damage 0.15	Sinking 0	46	0.00E+00								
					No sinking 1	47	5.55E-05	1.4							
				no severe damage 0.85	No sinking	48	3.14E-04	8.1							
		Breach hull 0.15	No breach db 0.78	severe damage 1	Sinking 0	49	0.00E+00								
					No sinking 1	50	5.09E-05	1.3							
				no severe damage 0	No sinking	51	0.00E+00								
			Breach db 0.22	severe damage 1	Sinking 0	52	0.00E+00								
					No sinking 1	53	1.44E-05	0.4							
				no severe damage 0	No sinking	54	0.00E+00								


Open Sea
0.09
loaded
0.80
No breach
0.50
severe damage
0.2
Sinking
0
No sinking
1
no severe damage
0.8
No sinking
55 0.00E+00
56 4.48E-05 1.2
57 1.79E-04 4.6
Breach hull
0.50
No breach db
0.78
severe damage
1
Sinking
0.17
No sinking
0.83
no severe damage
0
No sinking
58 2.97E-05 0.8 1 152191 82,500,000 2.97E-05 4.52E+00 2.45E+03
59 1.45E-04 3.7
60 0.00E+00
Breach db
0.22
severe damage
1
Sinking
0.17
No sinking
0.83
no severe damage
0
No sinking
61 8.37E-06 0.2 1 152191 82,500,000 8.37E-06 1.27E+00 6.91E+02
62 4.09E-05 1.1 10726 4.38E-01
63 0.00E+00
ballast
0.20
No breach
0.50
severe damage
0.2
Sinking
0
No sinking
1
no severe damage
0.8
No sinking
64 0.00E+00
65 1.12E-05 0.3
66 4.48E-05 1.2
Breach hull
0.50
No breach db
0.78
severe damage
1
Sinking
0.17
No sinking
0.83
no severe damage
0
No sinking
67 7.42E-06 0.2 1 82,500,000 7.42E-06 6.12E+02
68 3.62E-05 0.9
69 0.00E+00
Breach db
0.22
severe damage
1
Sinking
0.17
No sinking
0.83
no severe damage
0
No sinking
70 2.09E-06 0.1 1 82,500,000 2.09E-06 1.73E+02
71 1.02E-05 0.3
72 0.00E+00

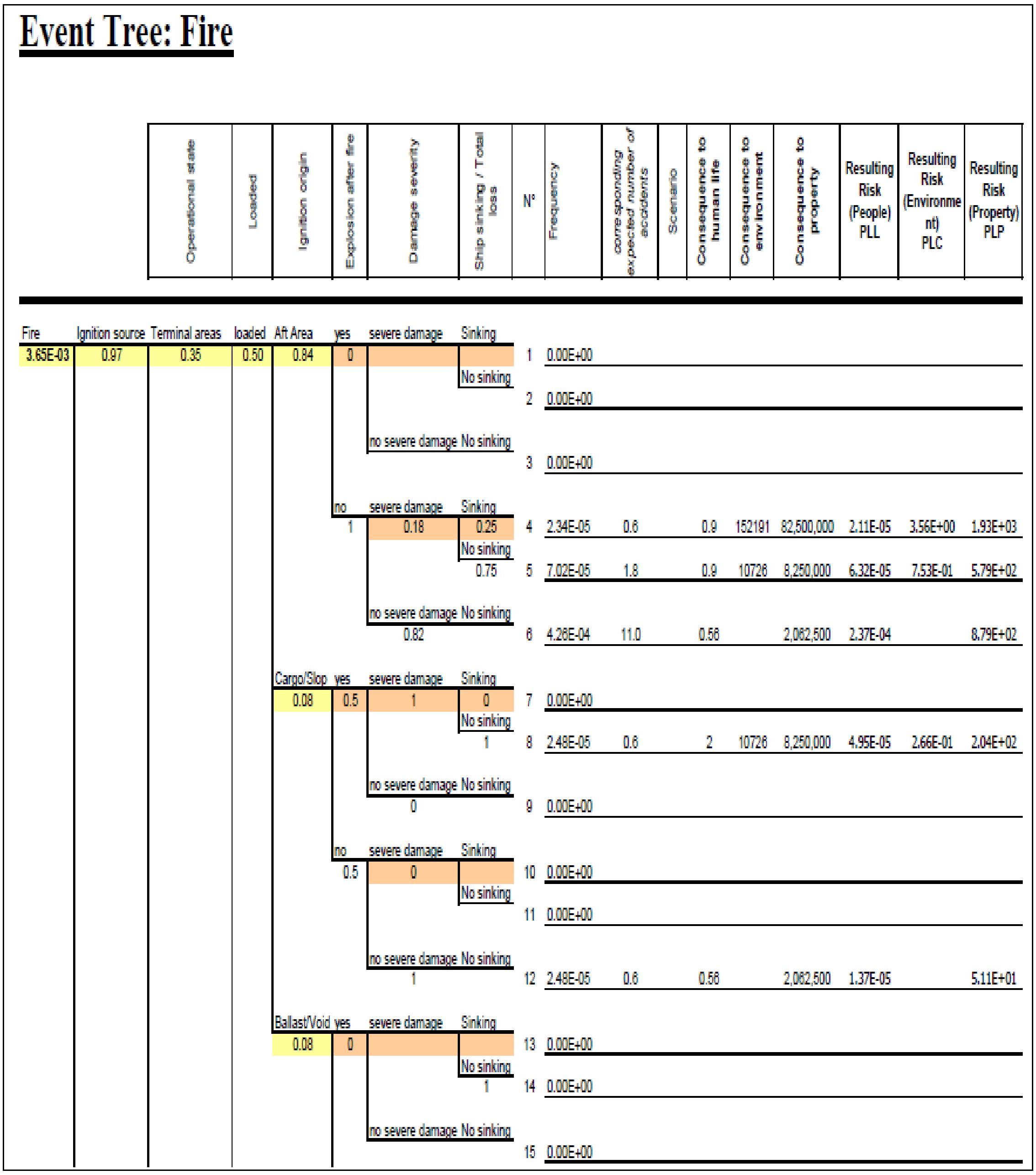
	Operational state	Loaded	No breach in hull	No breach double bottom	Damage severity	Ship sinking	N°	Frequency	corresponding expected number of accidents	Scenario	Consequence to human life	Consequence to environment	Consequence to property	Resulting Risk (People) PLL	Resulting Risk (Environment) PLC	Resulting Risk (Property) PLP
Drift 0.17	Terminal areas 0.28	loaded 0.80	No breach 0.75		severe damage 0.33	Sinking 0	73	0.00E+00								
						No sinking 1	74	7.06E-05	1.8							
					no severe damage 0.67	No sinking	75	1.43E-04	3.7							
			Breach hull 0.25	No breach db 0.78	severe damage 0.5	Sinking 0	76	0.00E+00								
						No sinking 1	77	2.78E-05	0.7							
					no severe damage 0.5	No sinking	78	2.78E-05	0.7							
				Breach db 0.22	severe damage 0.5	Sinking 0	79	0.00E+00								
						No sinking 1	80	7.84E-06	0.2			10726			8.41E-02	
					no severe damage 0.5	No sinking	81	7.84E-06	0.2							
		ballast 0.20	No breach 0.75		severe damage 0.33	Sinking 0	82	0.00E+00								
						No sinking 1	83	1.76E-05	0.5							
					no severe damage 0.67	No sinking	84	3.58E-05	0.9							
			Breach hull 0.25	No breach db 0.78	severe damage 0.5	Sinking 0	85	0.00E+00								
						No sinking 1	86	6.95E-06	0.2							
					no severe damage 0.5	No sinking	87	6.95E-06	0.2							
				Breach db 0.22	severe damage 0.5	Sinking 0	88	0.00E+00								
						No sinking 1	89	1.96E-06	0.1							
					no severe damage 0.5	No sinking	90	1.96E-06	0.1							

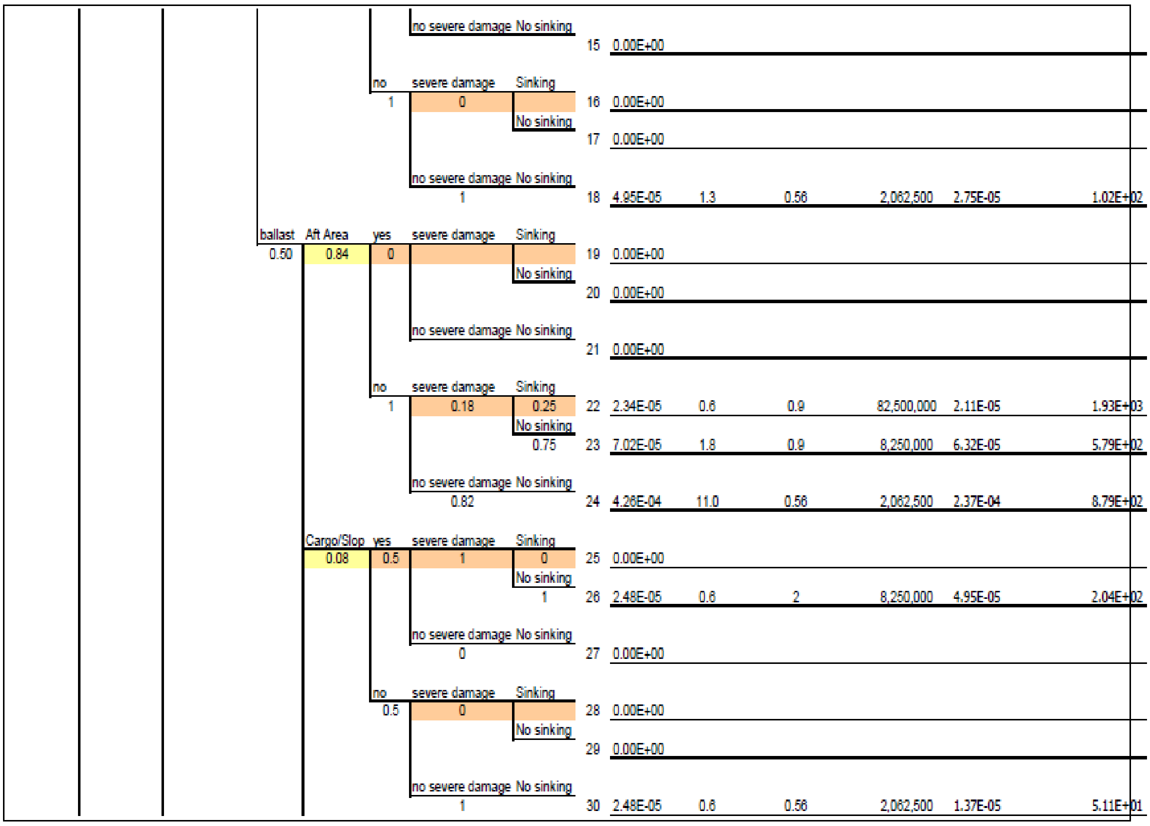

Congested waters loaded
0.28
0.80
No breach
0.50
severe damage
0.25
Sinking
0
91 0.00E+00
No sinking
1
92 3.57E-05 0.9
no severe damage No sinking
0.75
93 1.07E-04 2.8
Breach hull
0.50
No breach db
0.78
severe damage
1
Sinking
0.25
94 2.78E-05 0.7 152191 4.23E+00
No sinking
0.75
95 8.34E-05 2.2
no severe damage No sinking
0
96 0.00E+00
Breach db
0.22
severe damage
1
Sinking
0.25
97 7.84E-06 0.2 152191 1.19E+00
No sinking
0.75
98 2.35E-05 0.6 10726 2.52E-01
no severe damage No sinking
0
99 0.00E+00
ballast
0.20
No breach
0.50
severe damage
0.25
Sinking
0
100 0.00E+00
No sinking
1
101 8.91E-06 0.2
no severe damage No sinking
0.75
102 2.67E-05 0.7
Breach hull
0.50
No breach db
0.78
severe damage
1
Sinking
0.25
103 6.95E-06 0.2
No sinking
0.75
104 2.09E-05 0.5
no severe damage No sinking
0
105 0.00E+00
Breach db
0.22
severe damage
1
Sinking
0.25
106 1.96E-06 0.1
No sinking
0.75
107 5.88E-06 0.2
no severe damage No sinking
0
108 0.00E+00

Operational state	Loaded	No breach in hull	No breach double bottom	Damage severity	Ship sinking	N°	Frequency	corresponding expected number of accidents	Scenario	Consequence to human life	Consequence to environment	Consequence to property	Resulting Risk (People) PLL	Resulting Risk (Environment) PLC	Resulting Risk (Property) PLP
Limited waters 0.41	loaded 0.80	No breach 0.67		severe damage 0.75	Sinking 0	109	0.00E+00								
					No sinking 1	110	2.10E-04	5.4							
				no severe damage 0.25	No sinking	111	7.00E-05	1.8							
		Breach hull 0.33	No breach db 0.78	severe damage 1	Sinking 0	112	0.00E+00								
					No sinking 1	113	1.08E-04	2.8							
				no severe damage 0	No sinking	114	0.00E+00								
			Breach db 0.22	severe damage 1	Sinking 0	115	0.00E+00								
					No sinking 1	116	3.03E-05	0.8			10726			3.25E-01	
				no severe damage 0	No sinking	117	0.00E+00								
	ballast 0.20	No breach 0.67		severe damage 0.75	Sinking 0	118	0.00E+00								
					No sinking 1	119	5.25E-05	1.4							
				no severe damage 0.25	No sinking	120	1.75E-05	0.5							
		Breach hull 0.33	No breach db 0.78	severe damage 1	Sinking 0	121	0.00E+00								
					No sinking 1	122	2.69E-05	0.7							
				no severe damage 0	No sinking	123	0.00E+00								
			Breach db 0.22	severe damage 1	Sinking 0	124	0.00E+00								
					No sinking 1	125	7.58E-06	0.2							
				no severe damage 0	No sinking	126	0.00E+00								
Open Sea 0.03	loaded 0.80	Breach hull 1.00	No breach db 0.78	severe damage 1	Sinking 0	127	0.00E+00								
					No sinking 1	128	2.38E-05	0.6							
				no severe damage 0	No sinking	129	0.00E+00								
			Breach db 0.22	severe damage 1	Sinking 0	130	0.00E+00								
					No sinking 1	131	6.72E-06	0.2			10726			7.21E-02	
				no severe damage 0	No sinking	132	0.00E+00								
	ballast 0.20	Breach hull 1.00	No breach db 0.78	severe damage 1	Sinking 0	133	0.00E+00								
					No sinking 1	134	5.96E-06	0.2							
				no severe damage 0	No sinking	135	0.00E+00								
			Breach db 0.22	severe damage 1	Sinking 0	136	0.00E+00								
					No sinking 1	137	1.68E-06	0.0							
				no severe damage 0	No sinking	138	0.00E+00								

Source: MEPC, (2008)

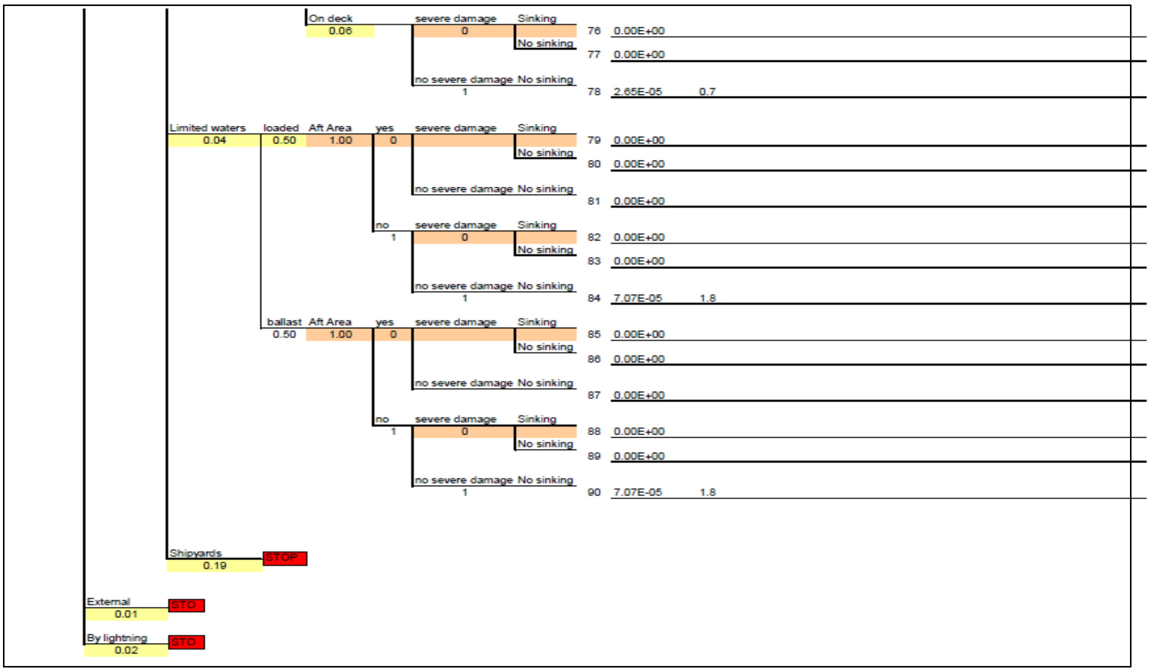
Appendix 10: Event tree - Fire




no severe damage No sinking
15 0.00E+00
no severe damage Sinking
1 0
16 0.00E+00
No sinking
17 0.00E+00
no severe damage No sinking
1
18 4.95E-05 1.3 0.56 2,062,500 2.75E-05 1.02E+02
ballast Aft Area yes severe damage Sinking
0.50 0.84 0
19 0.00E+00
No sinking
20 0.00E+00
no severe damage No sinking
21 0.00E+00
no severe damage Sinking
1 0.18 0.25
22 2.34E-05 0.6 0.9 82,500,000 2.11E-05 1.93E+03
No sinking
0.75
23 7.02E-05 1.8 0.9 8,250,000 6.32E-05 5.79E+02
no severe damage No sinking
0.82
24 4.26E-04 11.0 0.56 2,062,500 2.37E-04 8.79E+02
Cargo/Slop yes severe damage Sinking
0.08 0.5 1 0
25 0.00E+00
No sinking
1
26 2.48E-05 0.6 2 8,250,000 4.95E-05 2.04E+02
no severe damage No sinking
0
27 0.00E+00
no severe damage Sinking
0.5 0
28 0.00E+00
No sinking
29 0.00E+00
no severe damage No sinking
1
30 2.48E-05 0.6 0.56 2,062,500 1.37E-05 5.11E+01

Operational state	Loaded	Ignition origin	Explosion after fire	Damage severity	Ship sinking / Total loss	N°	Frequency	corresponding expected number of accidents	Scenario	Consequence to human life	Consequence to environment	Consequence to property	Resulting Risk (People) PLL	Resulting Risk (Environment) PLC	Resulting Risk (Property) PLP
		Ballast/Void 0.08	yes 0	severe damage	Sinking	31	0.00E+00								
					No sinking	32	0.00E+00								
				no severe damage	No sinking	33	0.00E+00								
			no 1	severe damage 0	Sinking	34	0.00E+00								
					No sinking	35	0.00E+00								
				no severe damage 1	No sinking	36	4.95E-05	1.3		0.56		2,062,500	2.75E-05		1.02E+02
Congested waters 0.17	loaded 0.50	Aft Area 0.91	yes 0.1	severe damage 0.5	Sinking 0.5	37	6.84E-06	0.2		2	152191	82,500,000	1.37E-05	1.04E+00	5.64E+02
					No sinking 0.5	38	6.84E-06	0.2		2	10726	8,250,000	1.37E-05	7.34E-02	5.64E+01
				no severe damage 0.5	No sinking	39	1.37E-05	0.4		0.56		2,062,500	7.59E-06		2.82E+01
			no 0.9	severe damage 0.57	Sinking 0	40	0.00E+00								
					No sinking 1	41	1.40E-04	3.6		0.9	10726	8,250,000	1.26E-04	1.51E+00	1.16E+03
				no severe damage 0.43	No sinking	42	1.06E-04	2.7		0.56		2,062,500	5.88E-05		2.18E+02
		Cargo/Slop 0.09	yes 0	severe damage	Sinking	43	0.00E+00								
					No sinking	44	0.00E+00								
				no severe damage	No sinking	45	0.00E+00								

Operational state	Loaded	Ignition origin	Explosion after fire	Damage severity	Ship sinking / Total loss	N°	Frequency	corresponding expected number of accidents	Scenario	Consequence to human life	Consequence to environment	Consequence to property	Resulting Risk (People) PLL	Resulting Risk (Environment) PLC	Resulting Risk (Property) PLP
			no 1	severe damage 1	Sinking 0	46	0.00E+00								
					No sinking 1	47	2.71E-05	0.7		0.9	10726	8,250,000	2.44E-05	2.90E-01	2.23E+02
				no severe damage 0	No sinking	48	0.00E+00								
	ballast 0.50	Aft Area 0.91	yes 0.1	severe damage 0.5	Sinking 0.5	49	6.84E-06	0.2		2		82,500,000	1.37E-05		5.64E+02
					No sinking 0.5	50	6.84E-06	0.2		2		8,250,000	1.37E-05		5.64E+01
				no severe damage 0.5	No sinking	51	1.37E-05	0.4		0.56		2,062,500	7.59E-06		2.82E+01
			no 0.9	severe damage 0.57	Sinking 0	52	0.00E+00								
					No sinking 1	53	1.40E-04	3.6		0.9		8,250,000	1.26E-04		1.16E+03
				no severe damage 0.43	No sinking	54	1.06E-04	2.7		0.56		2,062,500	5.88E-05		2.18E+02
		Cargo/Slop 0.09	yes 0	severe damage	Sinking	55	0.00E+00								
					No sinking	56	0.00E+00								
				no severe damage	No sinking	57	0.00E+00								
			no 1	severe damage 1	Sinking 0	58	0.00E+00								
					No sinking 1	59	2.71E-05	0.7		0.9		8,250,000	2.44E-05		2.23E+02
				no severe damage 0	No sinking	60	0.00E+00								
Open Sea 0.25	loaded 0.50	Aft Area 0.94	yes 0.06	severe damage 1	Sinking 0	61	0.00E+00								
					No sinking 1	62	2.49E-05	0.6		2	10726	8,250,000	4.99E-05	2.67E-01	2.06E+02
				no severe damage 0	No sinking	63	0.00E+00								
			no 0.94	severe damage 0.44	Sinking 0.57	64	9.80E-05	2.5		2	152191	82,500,000	1.96E-04	1.49E+01	8.08E+03
					No sinking 0.43	65	7.39E-05	1.9		2	10726	8,250,000	1.48E-04	7.93E-01	6.10E+02
				no severe damage 0.56	No sinking	66	2.19E-04	5.6		0.56		2,062,500	1.21E-04		4.51E+02
		On deck 0.06		severe damage 0	Sinking	67	0.00E+00								
					No sinking	68	0.00E+00								
				no severe damage 1	No sinking	69	2.65E-05	0.7							
	ballast 0.50	Aft Area 0.94	yes 0.06	severe damage 1	Sinking 0	70	0.00E+00								
					No sinking 1	71	2.49E-05	0.6		2		8,250,000	4.99E-05		2.06E+02
				no severe damage 0	No sinking	72	0.00E+00								
			no 0.94	severe damage 0.44	Sinking 0.57	73	9.80E-05	2.5		2		82,500,000	1.96E-04		8.08E+03
					No sinking 0.43	74	7.39E-05	1.9		2		8,250,000	1.48E-04		6.10E+02
				no severe damage 0.56	No sinking	75	2.19E-04	5.6		0.56		2,062,500	1.21E-04		4.51E+02

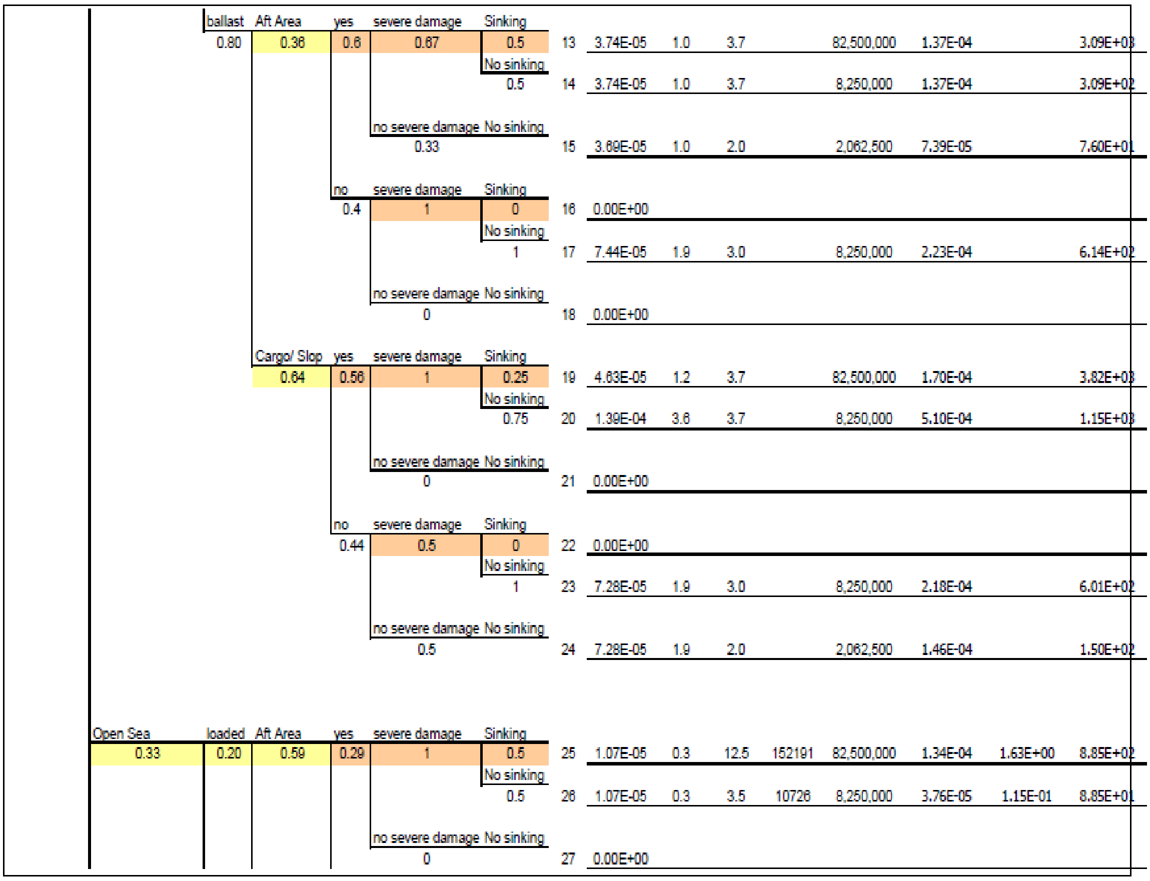


Source: MEPC, (2008)

Appendix 11: Event tree - Explosion

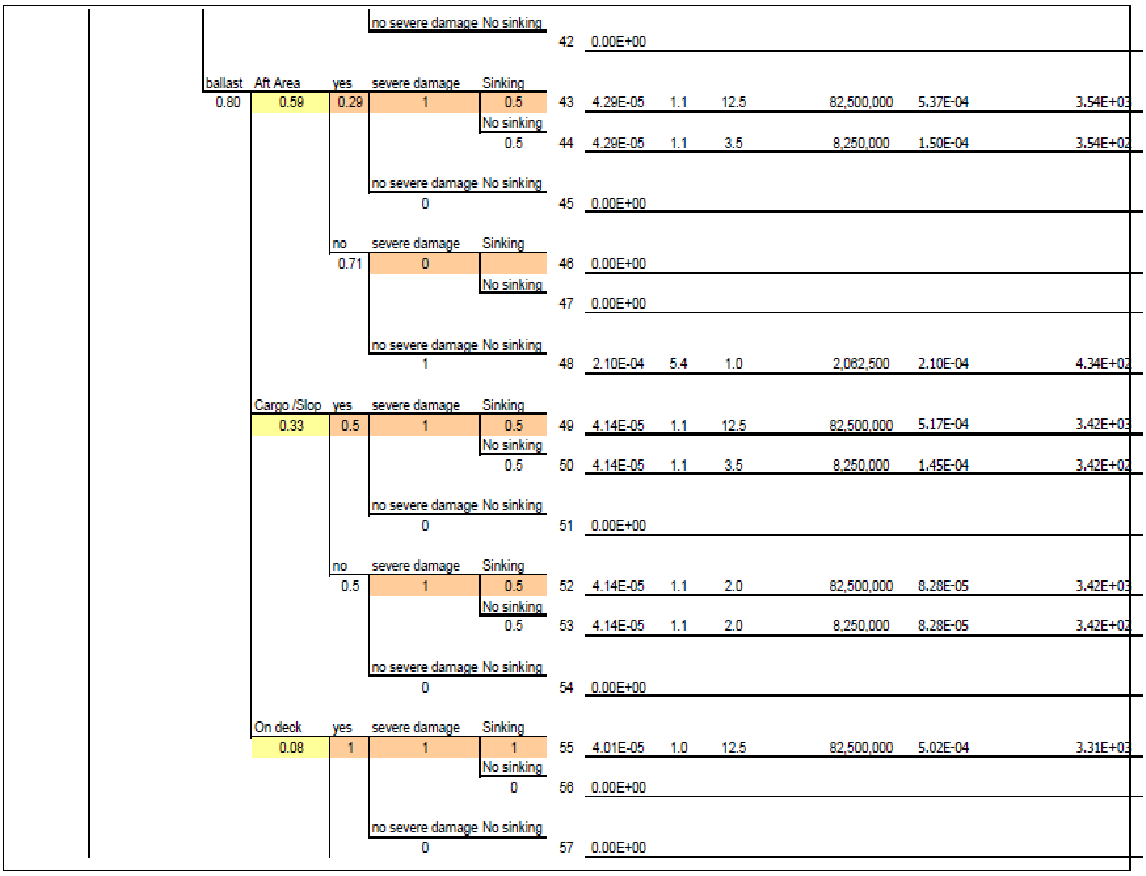
Event Tree: Explosion

	Operational state	Loaded	Ignition origin	Fire after Explosion	Damage severity	Ship sinking / Total loss	N°	Frequency	corresponding expected number of accidents	Consequence to human life	Consequence to environment	Consequence to property	Resulting Risk (People) PLL	Resulting Risk (Environment) PLC	Resulting Risk (Property) PLP
Explosion 1.90E-03	Terminal areas 0.34	loaded 0.20	Aft Area 0.36	yes 0.6	severe damage 0.67	Sinking 0.5	1	9.35E-06	0.2	3.7	152191	82,500,000	3.43E-05	1.42E+00	7.72E+02
						No sinking 0.5	2	9.35E-06	0.2	3.7	10726	8,250,000	3.43E-05	1.00E-01	7.72E+01
					no severe damage 0.33	No sinking	3	9.21E-06	0.2	2.0		2,062,500	1.85E-05		1.90E+01
				no 0.4	severe damage 1	Sinking 0	4	0.00E+00							
						No sinking 1	5	1.86E-05	0.5	3.0	10726	8,250,000	5.58E-05	2.00E-01	1.54E+02
					no severe damage 0	No sinking	6	0.00E+00							
			Cargo/ Slop 0.64	yes 0.56	severe damage 1	Sinking 0.25	7	1.16E-05	0.3	3.7	152191	82,500,000	4.25E-05	1.76E+00	9.55E+02
						No sinking 0.75	8	3.47E-05	0.9	3.7	10726	8,250,000	1.27E-04	3.73E-01	2.87E+02
					no severe damage 0	No sinking	9	0.00E+00							
				no 0.44	severe damage 0.5	Sinking 0	10	0.00E+00							
						No sinking 1	11	1.82E-05	0.5	3.0	10726	8,250,000	5.46E-05	1.95E-01	1.50E+02
					no severe damage 0.5	No sinking	12	1.82E-05	0.5	2.0		2,062,500	3.65E-05		3.75E+01



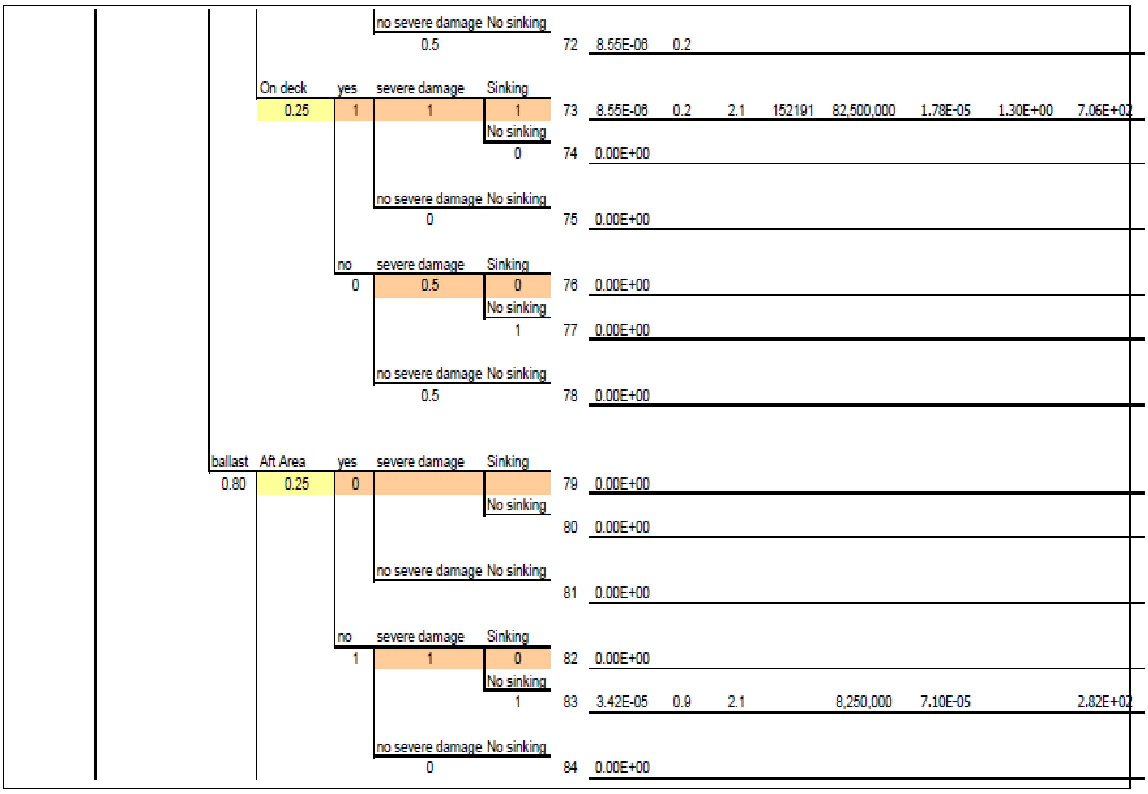
ballast
0.80
Aft Area
0.36
yes
0.6
severe damage
0.67
Sinking
0.5
13 3.74E-05 1.0 3.7 82,500,000 1.37E-04 3.09E+03
No sinking
0.5
14 3.74E-05 1.0 3.7 8,250,000 1.37E-04 3.09E+02
no severe damage
0.33
No sinking
15 3.69E-05 1.0 2.0 2,062,500 7.39E-05 7.60E+01
no
0.4
severe damage
1
Sinking
0
16 0.00E+00
No sinking
1
17 7.44E-05 1.9 3.0 8,250,000 2.23E-04 6.14E+02
no severe damage
0
No sinking
18 0.00E+00
Cargo/ Slop
0.64
yes
0.56
severe damage
1
Sinking
0.25
19 4.63E-05 1.2 3.7 82,500,000 1.70E-04 3.82E+03
No sinking
0.75
20 1.39E-04 3.6 3.7 8,250,000 5.10E-04 1.15E+03
no severe damage
0
No sinking
21 0.00E+00
no
0.44
severe damage
0.5
Sinking
0
22 0.00E+00
No sinking
1
23 7.28E-05 1.9 3.0 8,250,000 2.18E-04 6.01E+02
no severe damage
0.5
No sinking
24 7.28E-05 1.9 2.0 2,062,500 1.46E-04 1.50E+02
Open Sea
0.33
loaded
0.20
Aft Area
0.59
yes
0.29
severe damage
1
Sinking
0.5
25 1.07E-05 0.3 12.5 152191 82,500,000 1.34E-04 1.63E+00 8.85E+02
No sinking
0.5
26 1.07E-05 0.3 3.5 10726 8,250,000 3.76E-05 1.15E-01 8.85E+01
no severe damage
0
No sinking
27 0.00E+00

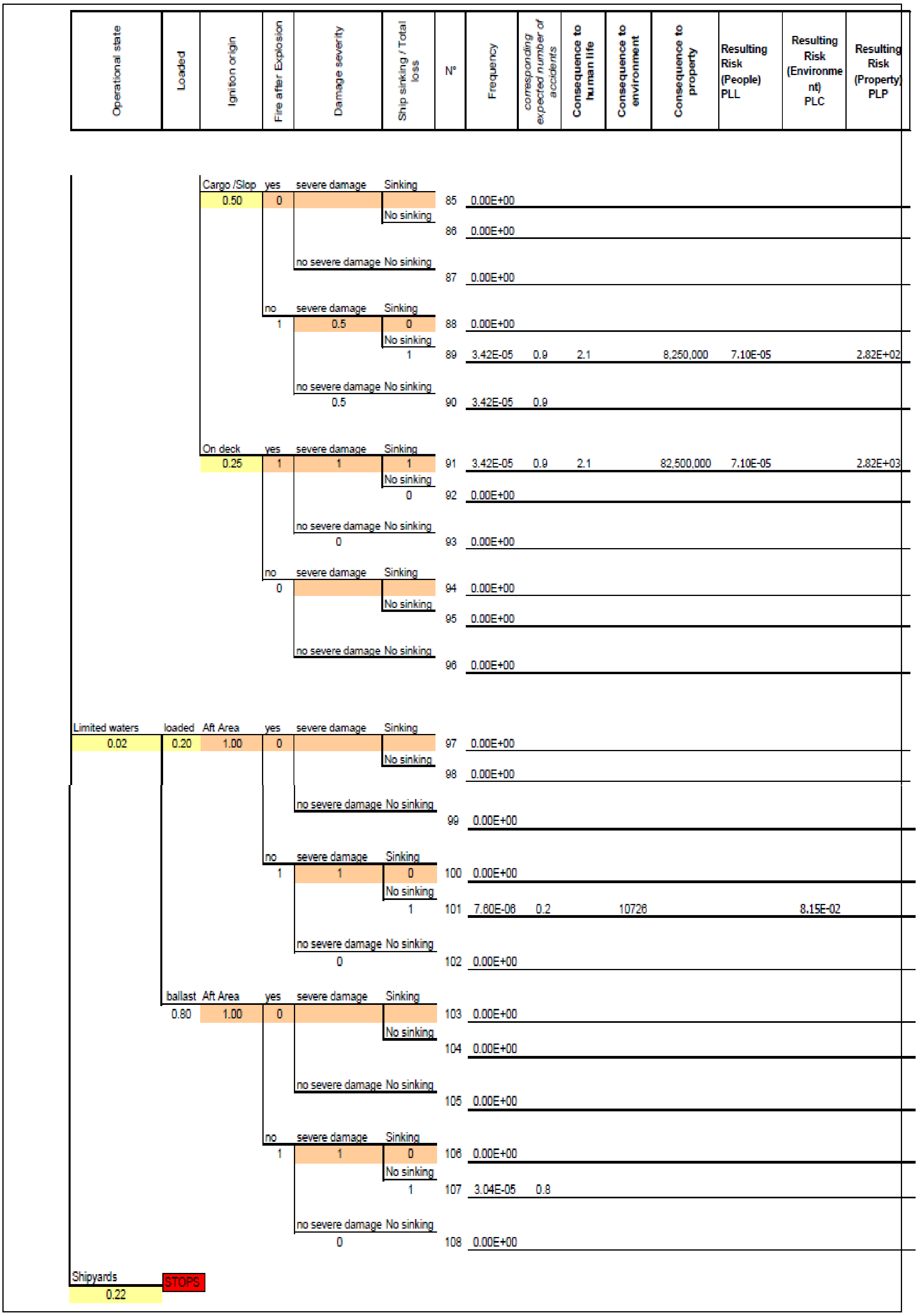
Operational state	Loaded	Ignition origin	Fire after Explosion	Damage severity	Ship sinking / Total loss	N°	Frequency	*corresponding expected number of accidents*	**Consequence to human life**	**Consequence to environment**	**Consequence to property**	**Resulting Risk (People) PLL**	**Resulting Risk (Environment) PLC**	**Resulting Risk (Property) PLP**
			no 0.71	severe damage 0	Sinking	28	0.00E+00							
					No sinking	29	0.00E+00							
				no severe damage 1	No sinking	30	5.25E-05	1.4	1.0		2,062,500	5.25E-05		1.08E+02
		Cargo /Slop 0.33	yes 0.5	severe damage 1	Sinking 0.5	31	1.03E-05	0.3	12.5	152191	82,500,000	1.29E-04	1.58E+00	8.54E+02
					No sinking 0.5	32	1.03E-05	0.3	3.5	10726	8,250,000	3.62E-05	1.11E-01	8.54E+01
				no severe damage 0	No sinking	33	0.00E+00							
			no 0.5	severe damage 1	Sinking 0.5	34	1.03E-05	0.3	2.0	152191	82,500,000	2.07E-05	1.58E+00	8.54E+02
					No sinking 0.5	35	1.03E-05	0.3	2.0	10726	8,250,000	2.07E-05	1.11E-01	8.54E+01
				no severe damage 0	No sinking	36	0.00E+00							
		On deck 0.08	yes 1	severe damage 1	Sinking 1	37	1.00E-05	0.3	12.5	152191	82,500,000	1.25E-04	1.53E+00	8.28E+02
					No sinking 0	38	0.00E+00							
				no severe damage 0	No sinking	39	0.00E+00							
			no 0	severe damage	Sinking	40	0.00E+00							
					No sinking	41	0.00E+00							



no severe damage No sinking
42 0.00E+00
ballast 0.80
Aft Area 0.59
yes 0.29
severe damage 1
Sinking 0.5
43 4.29E-05 1.1 12.5 82,500,000 5.37E-04 3.54E+03
No sinking 0.5
44 4.29E-05 1.1 3.5 8,250,000 1.50E-04 3.54E+02
no severe damage No sinking 0
45 0.00E+00
no 0.71
severe damage 0
Sinking
46 0.00E+00
No sinking
47 0.00E+00
no severe damage No sinking 1
48 2.10E-04 5.4 1.0 2,062,500 2.10E-04 4.34E+02
Cargo /Slop 0.33
yes 0.5
severe damage 1
Sinking 0.5
49 4.14E-05 1.1 12.5 82,500,000 5.17E-04 3.42E+03
No sinking 0.5
50 4.14E-05 1.1 3.5 8,250,000 1.45E-04 3.42E+02
no severe damage No sinking 0
51 0.00E+00
no 0.5
severe damage 1
Sinking 0.5
52 4.14E-05 1.1 2.0 82,500,000 8.28E-05 3.42E+03
No sinking 0.5
53 4.14E-05 1.1 2.0 8,250,000 8.28E-05 3.42E+02
no severe damage No sinking 0
54 0.00E+00
On deck 0.08
yes 1
severe damage 1
Sinking 1
55 4.01E-05 1.0 12.5 82,500,000 5.02E-04 3.31E+03
No sinking 0
56 0.00E+00
no severe damage No sinking 0
57 0.00E+00

Operational state	Loaded	Ignition origin	Fire after Explosion	Damage severity	Ship sinking / Total loss	N°	Frequency	corresponding expected number of accidents	Consequence to human life	Consequence to environment	Consequence to property	Resulting Risk (People) PLL	Resulting Risk (Environment) PLC	Resulting Risk (Property) PLP
			no 0	severe damage	Sinking	58	0.00E+00							
					No sinking	59	0.00E+00							
				no severe damage	No sinking	60	0.00E+00							
Congested waters 0.09	loaded 0.20	Aft Area 0.25	yes 0	severe damage	Sinking	61	0.00E+00							
					No sinking	62	0.00E+00							
				no severe damage	No sinking	63	0.00E+00							
			no 1	severe damage 1	Sinking 0	64	0.00E+00							
					No sinking 1	65	8.55E-06	0.2	2.1	10726	8,250,000	1.78E-05	9.17E-02	7.06E+01
				no severe damage 0	No sinking	66	0.00E+00							
		Cargo /Slop 0.50	yes 0	severe damage	Sinking	67	0.00E+00							
					No sinking	68	0.00E+00							
				no severe damage	No sinking	69	0.00E+00							
			no 1	severe damage 0.5	Sinking 0	70	0.00E+00							
					No sinking 1	71	8.55E-06	0.2	2.1	10726	8,250,000	1.78E-05	9.17E-02	7.06E+01


no severe damage No sinking
0.5
72 8.55E-06 0.2
On deck
0.25
yes
1
severe damage
1
Sinking
1
73 8.55E-06 0.2 2.1 152191 82,500,000 1.78E-05 1.30E+00 7.06E+02
No sinking
0
74 0.00E+00
no severe damage No sinking
0
75 0.00E+00
no
0
severe damage
0.5
Sinking
0
76 0.00E+00
No sinking
1
77 0.00E+00
no severe damage No sinking
0.5
78 0.00E+00
ballast
0.80
Aft Area
0.25
yes
0
severe damage
Sinking
79 0.00E+00
No sinking
80 0.00E+00
no severe damage No sinking
81 0.00E+00
no
1
severe damage
1
Sinking
0
82 0.00E+00
No sinking
1
83 3.42E-05 0.9 2.1 8,250,000 7.10E-05 2.82E+02
no severe damage No sinking
0
84 0.00E+00

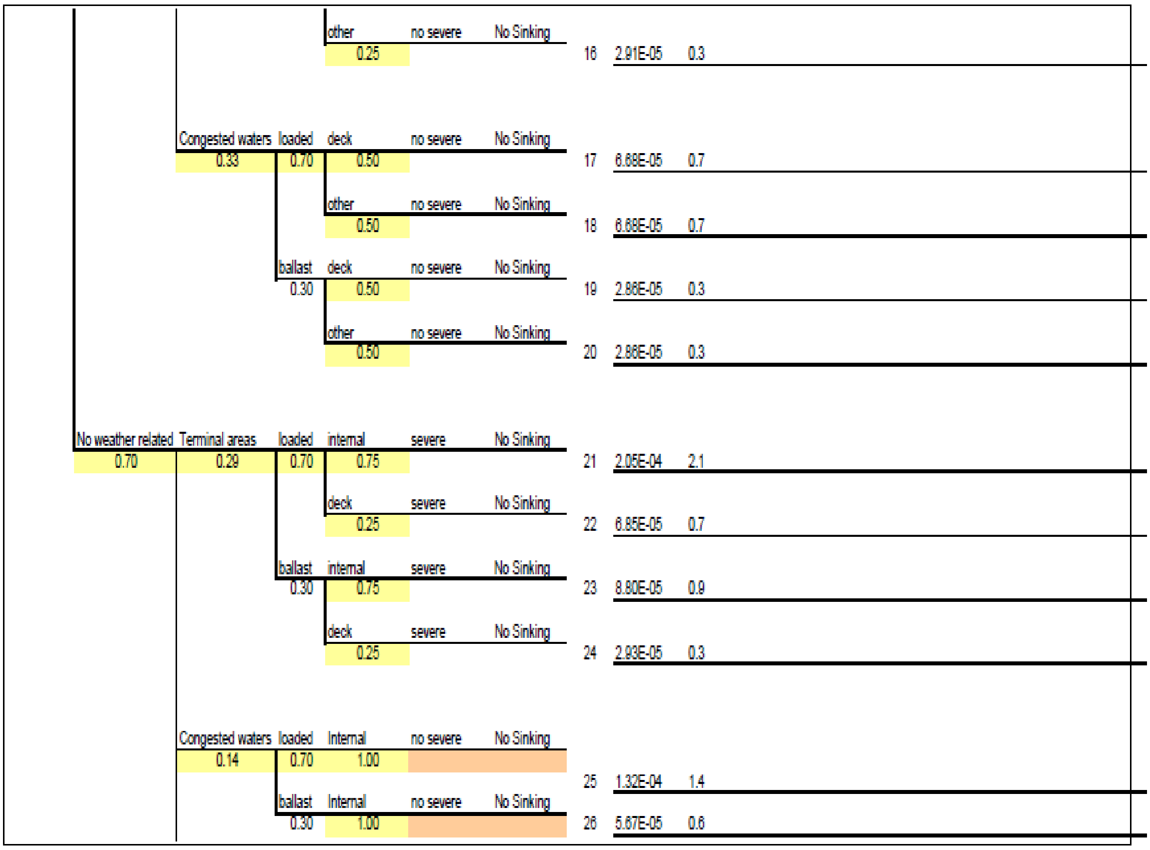


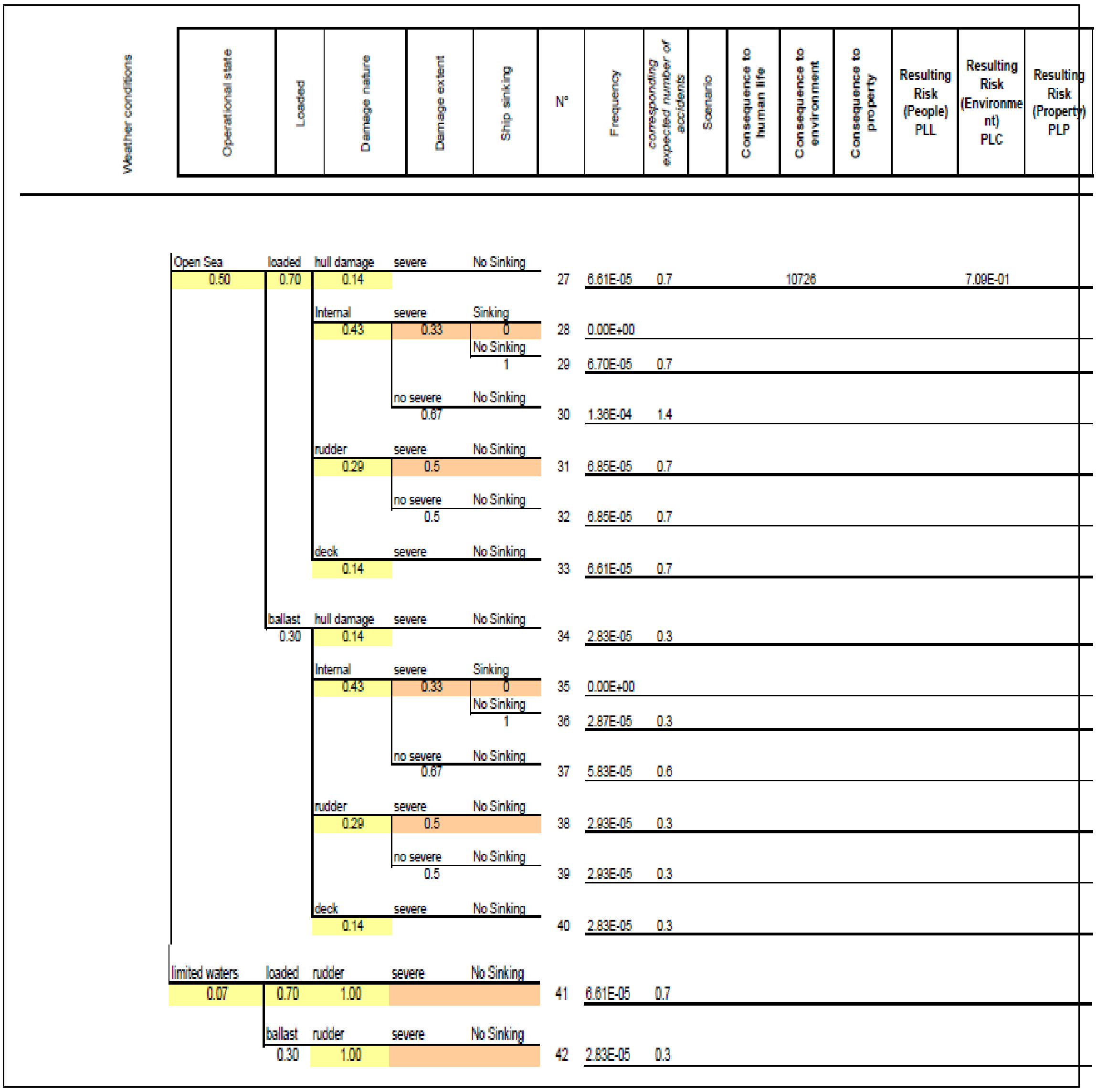
Source: MEPC, (2008)

Appendix 12: Event tree - Non-Accidental Structural failure

Event Tree: NASF

	Weather conditions	Operational state	Loaded	Damage nature	Damage extent	Ship sinking	N°	Frequency	corresponding expected number of accidents	Scenario	Consequence to human life	Consequence to environment	Consequence to property	Resulting Risk (People) PLL	Resulting Risk (Environment) PLC	Resulting Risk (Property) PLP
NASF 1.93E-03	Weather related 0.30	Open Sea 0.67	loaded 0.70	hull damage 0.25	severe 1	Sinking 0	1	0.00E+00								
						No Sinking 1	2	6.78E-05	0.7			10726			7.27E-01	
					no severe 0	No Sinking	3	0.00E+00								
				rudder damage 0.25	severe	No Sinking	4	6.78E-05	0.7							
				deck 0.25	severe 0	Sinking	5	0.00E+00								
						No Sinking	6	0.00E+00								
					no severe 1	No Sinking	7	6.78E-05	0.7		2		825,000	1.36E-04		5.59E+01
				other 0.25	no severe	No Sinking	8	6.78E-05	0.7							
			ballast 0.3	hull damage 0.25	severe 1	Sinking 0	9	0.00E+00								
						No Sinking 1	10	2.91E-05	0.3							
					no severe 0	No Sinking	11	0.00E+00								
				rudder damage 0.25	severe	No Sinking	12	2.91E-05	0.3							
				deck 0.25	severe 0	Sinking	13	0.00E+00								
						No Sinking	14	0.00E+00								
					no severe 1	No Sinking	15	2.91E-05	0.3		2		825,000	5.81E-05		2.40E+01


other
no severe
No Sinking
0.25
16 2.91E-05 0.3
Congested waters
0.33
loaded
0.70
deck
0.50
no severe
No Sinking
17 6.68E-05 0.7
other
0.50
no severe
No Sinking
18 6.68E-05 0.7
ballast
0.30
deck
0.50
no severe
No Sinking
19 2.86E-05 0.3
other
0.50
no severe
No Sinking
20 2.86E-05 0.3
No weather related
0.70
Terminal areas
0.29
loaded
0.70
internal
0.75
severe
No Sinking
21 2.05E-04 2.1
deck
0.25
severe
No Sinking
22 6.85E-05 0.7
ballast
0.30
internal
0.75
severe
No Sinking
23 8.80E-05 0.9
deck
0.25
severe
No Sinking
24 2.93E-05 0.3
Congested waters
0.14
loaded
0.70
Internal
1.00
no severe
No Sinking
25 1.32E-04 1.4
ballast
0.30
Internal
1.00
no severe
No Sinking
26 5.67E-05 0.6



Source: MEPC, (2008)

Appendix 13: DNV experts for RCO decisions

Name	Affiliation	Background
Arvind Phatak	DNV	Fire Safety expert/Master Mariner
Øyvind Lund-Johansen	DNV	Hydrodynamics expert
Bernt Hofset	DNV	Controls Systems expert
Matthew Seides	DNV	Ships in Operation/Tanker expert

Source: MEPC, (2008)